Planning cities for pandemics: a review of urban and transport planning lessons from COVID-19

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Abstract

For the past years, the world has been facing one of the worst pandemics of modern times. The COVID-19 outbreak joined a long list of infectious diseases that turned pandemic, and it will most likely leave scars and change how we live, plan, and manage the urban space and its infrastructures. Many fields of science were called into action to mitigate the impacts of this pandemic, including spatial and transport planning. Given the large number of articles recently published in these research areas, it is time to carry out an overview of the knowledge produced, synthesising, systematising, and critically analysing it. This article aims to review how the urban layout, accessibility and mobility influence the spread of a virus in an urban environment and what solutions exist or have been proposed to create a more effective and less intrusive response to pandemics. This review is split into two avenues of research: spatial planning and transport planning, including the direct and indirect impact on the environment and sustainability.

1. Introduction

On the last day of 2019, with the New Year's celebrations underway, a cluster of pneumonia cases of unknown causes was reported from Wuhan, Hubei province, China (WHO, 2020). From that moment, societies faced one of the worst pandemics of modern times. From all over the world and in different areas of knowledge, researchers started looking for solutions to reduce the spread of contagion while trying to adapt an unaware and unprepared society to a global pandemic. Urban areas become the centre of most outbreaks during these two years (Acuto, 2020): with over half of the world's population living in urban areas, most of which easily connect within each other and with each other (UN, 2018), cities became the main areas of concern for the rapid spread of the virus. This pandemic has impacted, arguably forever, our cities, as other pandemics in the past did (Eltarabily and Elgheznawy, 2020). Because spatial and transport planning certainly influences the spread of a virus in the urban environment, in the future, they must become part of short- and long-term solutions to other outbreaks of infectious diseases.

COVID-19 first caught the attention of urban and transport planners when a lockdown was declared in the city of Wuhan on January 23, 2020. Words such as social distancing and self-isolation started echoing worldwide at a stage where urban and transport planning was heading in a different, almost opposite direction; cities becoming denser, more compact and promoting transport planning policies aiming for higher public transport mobility and overall mass use. Inevitably, this led to an enormous COVID-19 impact on cities, as recognised by Krishna and Kummitha (2020). Cities thus face the daunting tasks of mitigating COVID-19 impacts, and spatial and transport planning are becoming frontrunners in this quest, as argued by Ibert et al. (2022) and, Tešić and Lukić (2020).

This article aims to review the state-of-the-art of research produced in spatial and transport planning concerning COVID-19, from its inception to the present, to summarise and analyse the main conclusions, and to suggest new avenues of research on the relationships between the urban layout, accessibility, mobility and the spread of a virus in an urban environment. The motivation for writing this review was to systematise the knowledge in the field, contributing by creating a coherent overview of the research landscape, filling a literature gap

on reviews of COVID-19 impacts on municipal engineering. Furthermore, it suggests future research lines which, as will be seen, cater for pandemics but also connect that aspect with other essential aspects of the urban environment, society, and sustainability. The following two chapters highlight the core role that both spatial and transport planning have during pandemic times and how COVID-19 might redirect research and change policies and practice in the short- and long term.

2. Spatial planning and COVID-19

Acuto (2020) and Ahsan (2020) have shown that spatial planning can have an essential role in the fight against COVID-19 and future pandemics by adapting to the new circumstances both in the short- and long-term. This section takes a closer look at how the theory and practice of spatial planning evolved due to COVID-19 and previous pandemics, highlighting the importance of green areas and parks in urban areas, how bigger cities have bigger problems and the disparities between developed and developing countries.

What has the past taught us; what does the future hold?

History has taught us about past pandemics, their origins, spread, and consequences. COVID-19 did not open a new area of research in this respect, but instead reopened one that had been dormant for many decades. Hays (2005) provides an overview of 50 epidemics and pandemics that Humans faced, from the epidemic in Athens in 430-427 BC to contemporary Malaria and Tuberculosis outbreaks. Looking at the timeline of all major pandemics, a worrisome statistic arises: from 430 BC to 2005, a total of 50 pandemics were recorded, while from 2005 to 2020, a total of six pandemics made worldwide news, a 25-fold increase in the frequency of pandemics. With the world population climbing, societies evolving and claiming previously uninhabited natural zones, the appearance and spread of new viruses have a higher potential for dire consequences, increasing the need for pre-emptive planning and prompt responses.

Pandemics have already led to changes in how the urban environment is planned and managed (Martínez and Short, 2021; Brinkley, 2020; Nanisetti, 2020; Füller, 2016). For example, when New York, Paris and London had cholera outbreaks, inhabitants searched for

open green and sunny areas, which led to the creation and design of buildings and outdoor areas to provide fresher air and sunlight (Klein, 2020; Antunes, 2021). The Garden City Movement is an example of urban planning acting as a tool to fight, among others, poor living conditions, lack of sanitation, and the Spanish flu of the XX century (Allam and Jones, 2020; Lai et al., 2020). In fact, several authors encouraged architectural and urban organisations to start including pandemics in disaster management strategies, with integrated containment measures in a seamless way, within the typical city environment (Allam and Jones, 2020; Paital, 2020; Salama, 2020). Bouffanais and Lim (2020) urged urban analysts and planners to understand the dynamics of city movement, as urban flows may help explain the spread of COVID-19 within the built environment. Martínez and Short (2021) suggested that urban spaces should be rethought and planned for safer and more sustainable cities, starting with parks and green areas in densely populated conurbations.

Green areas as physical and mental safety nets

The COVID-19 pandemic has imposed the necessity to stay home to extremely connected and mobility-based societies. Life in confinement was something that most people were not used to, which led to an increase in the number of people suffering from mental health issues (Amit et al., 2021). Psychological health factors that added to economic and social insecurities took an even bigger toll on people's lives (Mazza et al., 2020), with children suffering the most from forced confinement (Tomikawa et al., 2021).

The claustrophobic nature of many residences in urban environments resulted in an increased use of urban parks and green areas during lockdowns (Venter et al., 2021). Urban parks and green areas have proven to be essential to the well-being of residents, creating higher resiliency and overall quality of life for their nearby population (Cheng et al., 2021; Slater et al., 2020; Xie et al., 2020). In addition, travel patterns emerged that indicated people opt for parks close to their homes with a travel time under 10 minutes, reinforcing the importance of neighbourhood parks and green areas (Xie et al., 2020; Ugolini et al., 2020). These authors suggested creating networks of small decentralised parks and green areas accessible for everyone, allowing for easier interactions with nature and providing a place with clear mental and physical benefits. Private gardens were also proven to be important for residents,

emphasising the importance of both public and private gardens for improved resiliency (Poortinga, 2021; Marques et al., 2021).

Big cities, big problems

Internationally connected cities, i.e., cities that host international hubs, industry and companies, were typically more affected in comparison with smaller urban areas and rural zones. Because big cities directly correlate with international cities, large urban areas and metropolises became the main clusters for the spread of COVID-19 (Ahsan, 2020). Wuhan, Shanghai, Hong Kong, London, Milan, Madrid, Barcelona, New York and São Paulo, among many other cities worldwide, had the largest COVID-19 outbreaks. Even when infections appear in satellite cities or metropolitan areas, the outbreak tends to move towards the city, as was the case in Milan or Oporto.

The idea that population density and urban areas help the spread of COVID-19 has been a possibility ever since the appearance of the virus (Lui, 2020; Desai, 2020). Salama (2020) compared the spread of the previous SARS outbreak in 2003 and the current outbreak, underlining a positive correlation between higher density and rapid spread, which Peng et al. (2020) confirmed. Higher densities can relate to low per-capita income, space overcrowding, and poor access to healthcare, originating more outbreaks among poorly housed communities Lai et al. (2020). Higher-density neighbourhoods are also related to lower well-being during the pandemic, in comparison with lower-density neighbourhoods; lower-income neighbourhoods and areas of minority concentration with smaller dwellings, less green space and higher reliance on public transport were negatively associated with well-being (Mouratidis, 2022; Carrión et al., 2021; Hong et al., 2020; Hatef et al., 2020). In contrast, good accessibility to local facilities and better access to amenities and public health infrastructure have been positively associated with well-being and reduced vulnerabilities in high-density areas (Mouratidis, 2022; Mouratidis and Yiannakou, 2022; Sharifi and Khavarian-Garmsir, 2020). Lower density resulted in lower infection and death rates, as claimed by Hamidi et al. (2020) and Carozzi et al. (2020). The incongruity of compact planning transpires once more, suggesting it continuously needs to be addressed and improved, mainly in urban areas where informal settlements are the home for most of the residents.

Slums: a COVID-19 playground?

Already known for poor living conditions, slums, i.e., dense informal settlements, might be the least prepared urbanised areas to fight this pandemic, with a lack of basic infrastructure such as sewers, waste collection, drainage, or even clean drinking water (Corburn et al., 2020; Patel, A. 2020). An already bad situation has worsened considerably (Chigbu and Onyebueke, 2020). Obongha and Ukam (2020) analysed different settlement patterns in Nigerian cities, places of serious concern for epidemiologists, virologists, and planners. Due to a lack of urban planning policies, buildings are extremely close to each other, making it nearly impossible to have any social distancing. Bearing in mind the lack of space, overcrowding and imminent violence, social distancing and hygienic measures are impractical, leaving millions of people with even less protection from the rapid spread of COVID-19 (Cheshmehzangi, 2021; Martínez and Short, 2021; Corburn et al., 2020; Patel, 2020).

Slums are neither a problem caused by mismanaged urban planning nor are they solvable by urban intervention alone (Bolay, 2006). Its residents are economically vulnerable, and COVID-19 worsened that vulnerability, as Patel (2020) argued when looking at slums in Indian cities. This author also argued that Smart Cities solutions to better control the spread of the COVID-19 virus and one-size-fits-all measures will not work for slums. Instead, that author suggests that providing long-term solutions to reduce the vulnerability of marginalised populations is a prerequisite to making cities more resilient.

3. Transport planning and COVID-19

The COVID-19 pandemic had a massive impact on transport patterns, mostly due to the closing of international borders and country-scale lockdowns. Zhang & Zhang (2021) and Valenzuela-Levi et al. (2021) argued that some behavioural pattern changes might be long-term or even permanent. Analysing city mobility alterations during a lockdown is the first step to understanding how transport planning adapted to this new, unforeseen paradigm. Because cities host mobile populations, transport services, and foster social interactions, their intercity and intracity public transport systems increase a city's vulnerability to the spread of contiguous diseases (Carozzi et al., 2020; Lak et al., 2020), both at the hub locations (stations) and inside the transport vehicles, making it important to analyse the role of public transport

mid-pandemic. By contrast, active mobility has a small associated risk of contagion, which contributed to the reinforcement of its position on the urban transport agenda. Additionally, ripple effects in air pollution emerged, coming from changes in mobility patterns, which must be mentioned.

Mobility during lockdown

With the number of cases on the rise, cities worldwide underwent lockdown measures, enforced either by local or nationwide government decisions (Gargoum and Gargoum, 2021). With severe restrictions, urban transport was significantly reduced. Several works analysed the impact that the pandemic had on mobility, with public transport suffering from a drastic decrease in ridership, due to people preferring to use private transport, both motorised and non-motorized, for a reduced chance of contagion (Scorrano and Danielis, 2021; Aloi et al., 2020; Badii et al., 2020; Eisenmann et al., 2021). Nevertheless, people still needed to move, either to work, restock food, or for services, so not all trips could be curtailed (Borkowski et al., 2021).

Parr et al. (2020) showed that by March 22nd, 2020, during the state-wide Florida lockdown, traffic volumes went down an average of 47,5% in comparison to the homologous value in 2019, with urban areas all around the state exhibiting an earlier and more significant decline in traffic volumes in comparison with rural areas. Osservatorio Audimob (2020) analysed the impact of the COVID-19 lockdown on general trips in Italy, having found that during the worst pandemic stage, all-purpose countrywide mobility went down from an average of 85% in 2019 to just 32%. Those authors also concluded that proximity mobility, i.e., walking trips taking less than 5 minutes, went from 6% to 17%, while commuting and leisure trips went down from 91% to 49%. Fatmi (2020) found similar figures, with out-of-home activities in the Kelowna region of British Columbia, Canada, dropping over 50% during the COVID-19 pandemic. Aloi et al. (2020) presented a detailed analysis for the city of Santander, Spain. Overall results show that mobility plunged by over 76%, with the private car being the least affected and public transport being the most affected, with a staggering 93% reduction. A noteworthy by-product was the reduction of up to 67% of traffic accidents. That study also revealed an interesting change in modal share between pre- and post-pandemic times, with a rise from 48% to 77% of the private car and a reduction of 7,8% to 2,3% of public transport

trips. Commuting trips became the main reason for people to leave their homes, rising from 35% to 74% during the pandemic.

The pandemic also impacted commuters and the future of commuting. Singh et al. (2020) found a significant impact on how people view and perceive safety when travelling, with metro, carpool, and buses seeing a decline in modal share while walking and the private car rose their share. If so far choosing a mode of transport was mostly based on travel time, cost and overall convenience, the inconvenience of wearing masks or social distancing also became valid arguments (Samedi et al., 2021). Rubin et al. (2020) conducted an international online survey among individuals who regularly commuted to their workplace and concluded that 69% of the respondents miss at least some aspects of commuting, such as the commuting itself (53%), spending some time on their own (25%), or feeling independent (24%). People do not all miss commuting equally: those that frequently commute by private car are the least affected, with over 50% not missing commuting at all. As to public transport users, 75% do not miss commuting. Active transport users, e.g., (e-)cyclists and pedestrians, are the ones that miss commuting the most, 91%. Another interesting conclusion of Rubin et al. (2020) was that the more time a person had to spend commuting, the less that person would miss it.

Perhaps the most important question concerning the reduction in travelling and lockdowns is whether it impacted the spread of COVID-19. According to Gargoum and Gargoum (2021), it did: countries that were faster to respond had significantly lower mortality rates per 100 000 people and managed to implement less strict lockdown strategies. Furthermore, the study highlighted that there is a potential positive correlation between (i) *taking early action and lower mortality rates;* (ii) *taking early actions and being able to maintain a higher level of mobility and;* (iii) *taking early action and the potential of seeing an early recovery onset*, thus setting a benchmark on disaster relief actions.

COVID-19 and mobility patterns

Our hypermobile society has helped the virus contagion capability (Musselwhite et al., 2020). The virus quickly entered big international cities, rapidly spreading to the rest of the country, helped by the fact that people infected with COVID-19 become contagious before showing any symptoms or even being completely asymptomatic (Javid et al., 2020). A study by Badr et

al. (2020), based on daily mobility data from mobile phone data, has shown a strong correlation between mobility patterns and COVID-19 cases, with the lockdown resulting in lower mobility and consequently a decrease in COVID-19 case growth for those same areas. Additionally, changes in mobility patterns were only perceptible after 9-12 days of COVID-19 transmission, consistent with the incubation time of the virus (Badr et al., 2020). Similarly, Cartenì et al. (2020) performed a quantitative estimation through a multiple regression model to prove a connection between mobility and overall trips made within Italy and new COVID-19 positive cases.

The environmental flip side of standing still

High levels of air pollution in cities are a serious environmental issue that most cities worldwide have been facing for the past decades (Mayer, 1999). Several authors have found a positive correlation between air pollution levels and COVID-19 incidence and severity (Setti et al., 2020; Espejo et al., 2020; Sasidharan et al., 2020). The positive correlation between urban transport and air pollution is also well documented (Kumar et al., 2015; Shabbir and Ahmad, 2010), and indeed a reduction in travelling from lockdowns had a direct impact on pollution and air quality, despite the increase in the private car modal share. Lockdowns were, in fact, the first time in modern history that societies radically reduced global greenhouse emissions, improving both air and water quality (Sharifi and Khavarian-Garmsir, 2020; Mahato et al., 2020; Sharma et al., 2020; Gama et al., 2020; Abdullah et al., 2020; Xu et al., 2020; Nakada and Urban, 2020; Lian et al., 2020; Krecl et al., 2020; Dantas et al., 2020; Baldasano, 2020). With most of the cities in the world on lockdown, according to data from NASA (National Aeronautics and Space Administration) and ESA (European Space Agency), pollution lowered by up to 30% in COVID-19 epicentres such as Italy, Spain, Wuhan, or the USA (Muhammad et al., 2020). It is however unclear whether this new evidence can change the willingness and capability of worldwide governments to promote policies and changes in transport planning to improve air quality and overall sustainability (Sharma et al., 2020; Cadotte, 2020).

Public transport mid a pandemic

Several researchers agreed that public transport, as it was before COVID-19, was a prime space for person-to-person transmission (Teixeira and Lopes, 2020; Meyer and Elrahman,

2020; Gutiérrez et al., 2020; Musselwhite et al., 2020). Commuters are confined in small and limited spaces, which are more prone to transmission (WHO, 2020). If there is active contagion on public transport, it is impossible to identify the passengers who might have been in proximity to the person infected (Musselwhite et al., 2020). Both public transport vehicles and stations have multiple surfaces that are constantly used by several people: leaving seats, handrails, doors, and ticket machines easy virus transfer surfaces (Tirachini and Cats, 2020). Because of this, public transport was the most affected of all modes, both in terms of ridership and rider trust. Indeed, ridership plummeted all over the world, with examples such as Switzerland (90% decrease), Sweden (40%-60% across regions), Curitiba [Brazil] (80% decrease), or Santiago [Chile] (reduction in subway trips of 55% and 45% in bus trips) (Hörcher et al., 2021; Fumagalli et al., 2021; Thombre and Agarwal, 2021; Tirachini and Cats, 2020; Jenelius and Cebecauer, 2020; Molloy et al., 2020; Astroza et al., 2020).

COVID-19 temporarily brought to a halt ongoing endeavours by municipal authorities to promote and raise public transport ridership, creating new challenges for both authorities and commuters (Gutiérrez et al., 2020). Fear on the commuter side might take over, making it plausible that public transport is traded for other means of transport, as some reports have evidenced (Thomas et al., 2021; Przybylowski et al., 2021; Waka Kotahi NZ Transport Agency, 2020). In fact, Thombre and Agarwal (2021) and Das et al. (2021) found an increase in car dependency, with people willing to shift towards the private car. Such a shift is, however, not desired; as Dong et al. (2021) state, in a health crisis, public transport should protect passengers while still meeting travelling demand, improving their operational modes by increasing service frequency and ensuring physical distance among passengers. At this stage, it is still uncertain what the ramifications and long-term impacts of the pandemic truly are for public transport. However, the fostering of higher ridership levels has become more problematic.

Walking and cycling: towards a post-COVID-19 future?

As lockdowns were enforced, walking and cycling were seen by many as resilient and reliable modes of transport with a small risk of contagion. Cities observing this phenomenon started promoting cycling by creating new and additional bike lanes, reducing the prices of bike-sharing systems, restricting car circulation, and creating incentives for bicycle purchases

(Büchel et al., 2022; Kraus and Koch, 2021; Barbarossa, 2020). Zhang and Zhang (2021) argued that the disruptions in spatial and transport planning might make it the right time for active mobility to seize the opportunity and gain even more momentum. This trend was also supported by recent research relating COVID-19 and active transport, which advocated for greater support and implementation of active transport solutions (Büchel et al., 2022; Rubin et al., 2020; De Vos, 2020; Musselwhite et al., 2020; Lak et al., 2020; Laverty et al., 2020; Singh et al., 2020). On the field, local and international entities are prompting green solutions aiming for the decline in car-based transport infrastructure in exchange for adequate cycling infrastructure (Cheshmehzangi, 2021).

Research by Teixeira et al. (2021) has shown that despite decreasing ridership, bicycle-sharing systems have higher resiliency in comparison to public transport, and compelling evidence surfaced of a modal shift from public transport to bicycle ridership (Nikiforiadis et al., 2020; Teixeira and Lopes, 2020) and active mobility in general (Harrington and Hadjiconstantinou, 2022; Lock, 2020). This is a positive sign for low and middle-income countries, where public transport is often overloaded. Higher shares of walking and cycling can be beneficial by reducing public transport pressure (Koehl, 2020).

More and more cities are including active mobility in their agendas, and this pandemic brought an opportunity for higher commitment alongside new and improved solutions. Cities in Italy, such as Turin, Naples, Milan, Bari, and Palermo, are actively working on post-COVID mobility solutions (Barbarossa, 2020). England and France also recognised the opportunity and created investment packages for a new era of cycling (Buehler and Pucher, 2021; Brooks et al., 2020). Findings by Thombre and Agarwal (2021) indicate that building new infrastructure can increase bicycle share from 31% to approximately 44% in India. Openness to new transport policies in favour of new car restrictions, more pedestrian space, and a switch to more sustainable mobility gained more acceptance during the pandemic compared to normal circumstances (Awad-Núñez et al., 2021). The lockdown period drove a collective reflection on sustainability, which on its own, provides an important window of opportunity for change (Awad-Núñez et al., 2021; Shaer et al., 2021; Sui and Prapavessis, 2020; Sharifi and Khavarian-Garmsir, 2020; Goetsch and Quiros, 2020; Huet, 2020; Ro, 2020; Dhillon, 2020; Wood, 2020), and more attention to the promotion and implementation of active transport

mobility (Budd and Ison, 2020; Nelson, 2020). It is now imperative to develop temporary and permanent new policies (Cheshmehzangi, 2021; Buehler and Pucher, 2021), which, if successful, might generate between $1 and $7 billion in health benefits per year (Kraus and Koch, 2021). A study by Buehler and Pucher (2022) analysed and compared bicycle levels between 2019 and 2021 from fourteen different cities and concluded that cycling levels generally increased from 2019 to 2021, mostly due to recreational and exercise trips, while cycling trips to work and education declined.

To achieve higher levels of sustainability in a post-COVID-19 era, urban transport policies must aim for higher resiliency, social equity, and decarbonisation (Valenzuela-Levi et al., 2021). Those authors show that some of these objectives may be achieved by combining adequate housing location and cycling promotion in an integrated policy. This suggestion was corroborated in recent research, which used quantitative arguments to argue that planned urbanism is a possible path to achieve equity and decarbonisation (Monteiro et al., 2022).

4. Conclusions and future work

Cities face new and daunting challenges in the post-COVID-19 era, with spatial and transport planning in the spotlight of a society that needs and must change (Ibert et al., 2022; Tešić and Lukić, 2020). Difficult and unusual decisions had to be taken during the pandemic, with limited knowledge by those taking them. Two years into the pandemic, that knowledge began to take shape, with numerous articles published concerning COVID-19 and pandemics in general, including those dealing with urban and transport planning issues. This review showed that the consequences of pandemics are now better understood at that level, and clear city planning implications begin to emerge. It was also seen that research at the beginning of the pandemic was mostly theoretical since little to no field data was available and that current research is starting to take a more practical approach. Concomitantly, new avenues of research have been opened for both academics and practitioners. Table 1 below summarises the main findings of this review and suggests directions for future research work concerning planning cities for pandemics. Figure 1 presents a visual framework for the findings, noting that the suggested links should be taken with a grain of salt since in an urban environment everything is interconnected; the links show only what are arguably the strongest

relationships. An extensive description of the multiple aspects found in COVID-19 research articles related to spatial and transport planning is presented in Table 2 (appendix).

Table 1. Conclusions and Research Opportunities.

Conclusion	**Research Opportunities**
C1. Disaster management plans for urban environments should include provisions for pandemic health crises.	R1. Design efficient and seamless lockdown areas based on spatial and transport planning procedures to prevent mass contagion.
C2. Large and dense built environments propitiate disease contagion.	R2. Deepening the link between contagion and compact development/high density living.
C3. Proximity-based parks and green areas mitigate lockdown effects.	R3. Development of methodologies which combine active accessibility to parks and green areas with contagion risk when those areas are small.
C4. The different and harsh reality of informal settlements does not fit in the typical solution for developed countries urban areas.	R4. Develop specific solutions for contagion mitigation in informal settlements. Monitor the efficacy of the solutions in the field.
C5. Lockdown-induced traffic reduction directly led to a reduction of air pollution and air quality improvement. A world-scale impact that would otherwise not be experienced.	R5. Use of data collected during lockdown for transport planning, mobility, and air quality analyses.
C6. COVID-19 added a health safety dimension to the choice of transport mode.	R6. Scrutinize the impact that this new perception has on commuters.
C7. Public transport experiences ridership losses during pandemics due to fear of contagion. The task of promoting and improving public transport became harder.	R7. Investigate effects of social distancing and respiratory etiquette on contagion within public transport. Issue recommendations to transport authorities.
C8. Active mobility, e.g., walking and cycling have proven to be safe and resilient modes of transport in urban areas.	R8. Use active accessibility studies to optimize the deployment of urban facilities. Work together with municipal authorities to design and implement cycling and pedestrian network infrastructure.

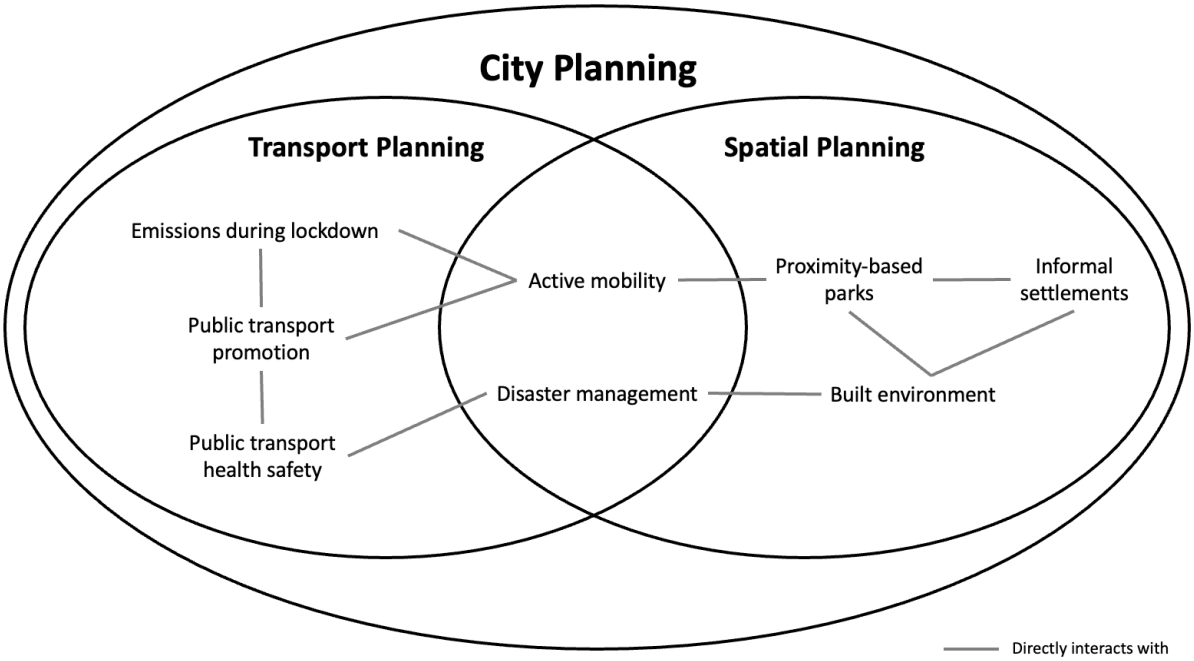

Figure 1 – Findings framework

Researchers are aware that there will be more pandemics in the future, and when that time comes, societies need to be prepared. As Rojas-Rueda and Morales-Zamora (2021) also concluded in their literature review:

> "*COVID-19 offers an opportunity to rethink the built environment and transport infrastructure with the aim to support short-term mitigation strategies and reduce long-term urban health inequities".*

Research may look in a holistic manner at the future of our society, our cities, our mobility, and high interconnectivity, learning from this pandemic, the mistakes, and the right calls. If done properly, spatial and transport planning can mitigate mass disease dissemination, possibly even helping epidemiologists trace high-risk contacts while simultaneously catering for other urban and societal needs in the perpetual quest of achieving higher resiliency and sustainability for all.

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APPENDIX

Table 2. COVID-19 related research articles in Spatial and Transport Planning.

	Location	COVID-19 Timeline	Past pandemics, their impacts and timeline	COVID-19 impact on urban areas	COVID-19 consequences on mental health and safety perception	Spatial planning					Transport planning					
						General urban planning considerations	Lessons learned from the COVID-19 pandemic	Urban planning as a tool to fight the COVID-19 and future pandemics	Green areas as physical and mental safety nets during COVID-19 lockdown	The impact of density, compactness, and world connection on the spread of COVID-19	General urban transport considerations	Travel patterns under COVID-19 lockdown	The role of accessibility and proximity	Public transport and COVID-19	Active mobility and COVID-19	COVID-19 and the environment flip side
Abdullah et al., 2020	Malaysia															X
Acuto, 2020	Global	X						X								
Ahsan, 2020	Turkey							X		X						
Allam & Jones, 2020a	Global		X				X	X								
Aloi et al., 2020	Santander										X	X				
Amit et al., 2021	Bangladesh				X											
Antunes, 2021	Global							X	X							
Astroza et al., 2020	Chile											X		X		
Awad-Núñez et al., 2021	Spain					X					X				X	
Badii et al., 2020	Florence											X				
Badr et al., 2020	USA	X										X				
Baldasano, 2020	Barcelona/Madrid															X
Barbarossa, 2020	Italy			X											X	
Bolay, 2006	Slums					X										
Borkowski et al., 2021	Poland										X	X				
Brinkley, 2020	Singapore		X				X									
Brooks et al., 2020	USA										X				X	
Büchel et al., 2022	United Kingdom														X	
Budd & Ison, 2020	Basel/Zurich					X					X				X	
Buehler & Pucher, 2021	Global										X				X	
Buehler and Pucher (2022)	Europe/USA		X	X							X	X			X	
Carozzi et al., 2020	USA										X		X			
Carrión et al., 2021	New York City									X						
Cartenì et al., 2020	Italy	X		X								X				
Cheng et al., 2021	Nanjing City						X		X							
Cheshmehzangi, 2021	Global									X					X	X
Corburn et al., 2020	Slums									X						
Dantas et al., 2020	Rio de Janeiro															X
De Vos, 2020	Global										X				X	
Desai, 2020	Global									X						
Dhilon, 2020	India					X					X					
Dong et al., 2021	China													X		
Eisenmann et al., 2021	Germany											X		X		
Eltarabily & Elgheznawy, 2020	Global		X				X									
Espejo et al., 2020	Global															X
Fatmi, 2020	British Columbia											X				
Füller, 2016	Hong Kong		X													

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Fumagalli et al., 2021	Curitiba											X		X		
Gama et al., 2020	Portugal															X
Gargoum and Gargoum, 2021	Global	X		X							X	X				
Goetsch & Quiros, 2020	Global					X					X					
Guitíerrez et al., 2020	Global														X	
Hamidi et al., 2020	USA									X						
Harrington & Hadjiconstantinou, 2022	UK														X	
Hatef et al., 2020	USA									X						
Hays, 2005	New York		X													
Hong et al., 2020	Global									X						
Hörcher et al., 2021	Global											X		X		
Huet, 2020	Europe					X					X					
Ibert et al., 2022	Global			X			X									
Javid et al., 2020	Global	X		X												
Jenelius & Cebecauer, 2020	Sweden											X		X		
Klein, 2020	New York								X							
Koehl, 2020	Global													X	X	
Kraus & Koch, 2021	Europe														X	
Krecl et al., 2020	São Paulo															X
Krishna & Kummitha, 2020	Global			X												
Kumar et al., 2015	Global										X					
Lai et al., 2020	Global		X							X						
Lak et al., 2020	Global										X				X	
Laverty et al., 2020	UK										X				X	
Lian et al., 2020	Global															X
Lock, 2020	Australia														X	
Lui, 2020	China									X						
Mahato et al., 2020	India															X
Marques et al., 2021	Rio de Janeiro				X		X		X							
Martínez & Short, 2021	Global		X	X						X						
Mayer, 1999	Global					X										
Mazza et al., 2020	Italy				X											
Meyer & Elrahman, 2020	Global														X	
Molloy et al., 2020	Switzerland											X		X		
Mouratidis & Yiannakou, 2022	Greece												X			
Mouratidis, 2022	Norway									X			X			
Muhammad et al., 2020	Global															X
Musselwhite et al., 2020	Global	X		X						X					X	
Nakada and Urban, 2020	São Paulo															X
Nanisetti, 2020	India		X													

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Nelson, 2020	Global					X					X				X	
Nikiforiadis et al., 2020	Thessaloniki														X	
Obongha and Ukam, 2020	Nigeria									X						
Osservatorio Audimob, 2020	Italy											X				
Paital, 2020	Global							X								
Parr et al., 2020	Global											X				
Patel, 2020	India									X						
Peng et al., 2020	Wuhan									X						
Poortinga, 2021	UK						X		X							
Przybylowski et al., 2021	Gdansk													X		
Ro, 2020	Global					X					X					
Rojas-Ruedas & Morales-Zamora, 2021	Global			X		X	X	X			X					X
Rubin et al., 2020	Global				X							X			X	
Salama, 2020	Global						X	X		X						
Samedi et al., 2021	Global South				X									X		
Sasidharan et al., 2020	London															X
Scorrano and Danielis, 2021	Trieste											X			X	
Setti et al., 2020	Bergamo															X
Shabbir & Ahmad, 2010	Pakistan										X					
Shaer et al., 2021	Shiraz					X					X					
Sharifi & Khavarian-Garmsir, 2020	India												X			X
Sharma et al., 2020	Global										X					X
Singh et al., 2020	Global				X						X	X		X	X	
Slater et al., 2020	Global						X	X	X							
Sui & Prapavessis, 2020	Canada					X					X					
Teixeira & Lopes, 2020	New York															
Teixeira et al., 2021	Lisbon											X		X	X	
Tešić & Lukić, 2020	Global			X			X	X								
Thomas et al., 2021	New Zealand													X		
Thombre & Agarwal, 2021	India											X		X		
Tirachini & Cats, 2020	Global											X		X		
Tomikawa et al., 2021	Tokyo				X											
Ugolini et al., 2020	Europe						X					X				
UN, 2018	Global					X										
Valenzuela-Levi et al., 2021	Santiago Chile											X				
Venter et al., 2021	Norway				X				X							
Waka Kotahi NZ Transport Agency, 2020	New Zealand													X		

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						Spatial planning					Transport planning					
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WHO, 2020	Global	X		X										X		
Wood, 2020	Global					X					X					
Xie et al., 2020	Chengdu						X	X	X			X				
Xu et al., 2020	China															X
Zhang & Zhang, 2021	Global											X			X	
TOTAL	-----	7	9	12	8	14	13	10	8	17	25	26	4	17	25	17