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Review

Examining Post-Pandemic Urban Transformations: A Literature Review on COVID-19's Influence on Urban Design

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Abstract: Background: Urban areas attract people looking to improve their quality of life. However, the urban territory has been organised without respect for biogeophysical support or a holistic strategy for distributing populations and activities in the available space. Recent urbanisation models, such as compact city approaches, were designed to enhance cities' sustainability and resilience. However, the COVID-19 pandemic has raised questions about how these models can still influence the spread of infectious diseases within urban spaces. Methodology: To investigate the impact of COVID-19 on the reassessment of urbanisation models to promote health and wellbeing, a comprehensive literature review was conducted to analyse the interventions implemented and documented in scientific research by several cities in the wake of the pandemic. Results: The analysis emphasises the city's dedication to expanding open public urban spaces, preferably with closer access to nature, and potentialising its use, especially during times of lockdown. Conclusions: The effects of the interventions reported in the selected studies on urban communities are not yet known. Most of the interventions reported are not yet being/have not been monitored to understand their results on COVID-19 contagion.

Keywords: urbanisation; infectious diseases; public health; urban health

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1. Introduction

Throughout history, countless moments have left their mark on public health, shaping the course of society. Dating back to the earliest times, the first recorded pandemic occurred in the 11th century with the Antonine Plague, marking the beginning of a series of events that would shape the global health landscape [1]. These moments of great impact on public health have become more recurrent, challenging the resilience of communities, as cities worldwide must continually adapt to protect public health (Figure 1).

Over the centuries, the world has witnessed increasing interconnectedness and complexity, driven by technological advances and facilitated by globalised interactions [2]. This multifaceted scenario brings complex challenges and a call for more holistic approaches to address the social and public health implications of a highly connected world [3]. Pandemic episodes, for example, have historically triggered major shifts in spatial planning, leading to health reforms and the development of more resilient infrastructures and communities capable of absorbing, adapting to, and transforming in response to public health crises [4–7].

At a global level, urbanisation has proven to be a significant and ongoing phenomenon as cities strive to accommodate demographic dynamics and lifestyles. According to data from the "World Population Prospects" report [8], more than 55 per cent of the global population currently lives in urban areas, with this proportion projected to exceed 68 per cent by 2050. These trends underscore the importance of preparing urban spaces that can sustainably manage both growth and public health resilience in the face of future challenges and their different characteristics [9,10].

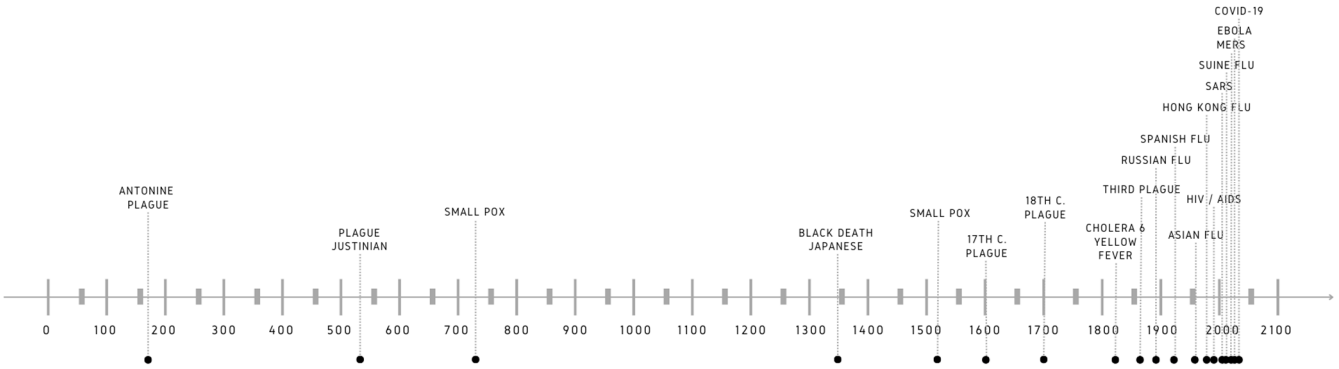

Figure 1. Chronology of the main pandemics reported in history (adapted from Sara Eltarabily and Dalia Elgheznawy, 2020) [1].

Early in the scientific literature, there was a continuous effort to systematise the factors contributing to disease spread within urban environments. This effort sought to understand the health determinants that play a crucial role in shaping community health [11,12]. Among these determinants, urban design and planning have been increasingly recognised for their significant impact on health outcomes, particularly in promoting healthy urbanism [13,14]. However, although comprehensive conceptual models for these determinants exist, such as the widely discussed model developed by Whitehead and Dahlgren [15] and updated by Barton and Grant [16], it has been found that not all of them are easily quantifiable, and the weighting between them is a complex task. Yet, it is widely acknowledged that urban environments significantly influence community vulnerability to infectious diseases [17–19] (Figure 2).

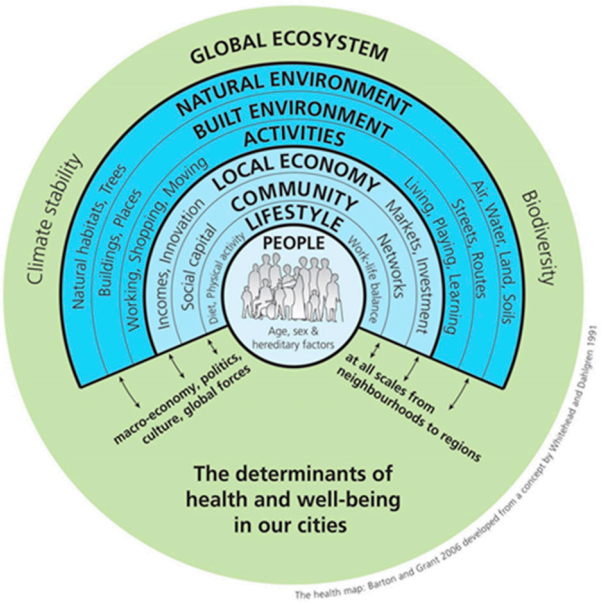

Figure 2. Conceptual framework "The Determinants of health and well-being in our neighbourhoods" (Barton e Grant, 2006) [16].

The COVID-19 pandemic has emerged as an unprecedented challenge, abruptly suspending the lives of the entire global population [20]. At a time when it was inconceivable that anything could halt the daily functioning of the world, COVID-19 revealed vulnerabilities within urban environments and the urgent need to reconsider strategies for safeguarding public health in an interconnected world [21].

This event has led to the emergence of new issues that challenge established norms for urban dynamics around the world [22–25]. The way urbanism is thought of has

become a central element in enabling the territory and population to adapt to this major transformation [26].

This literature review seeks to explore how cities are responding to the COVID-19 pandemic by adapting their structures and dynamics to meet this global health challenge. By reviewing the interventions implemented and documented in the scientific literature, this study aims to provide insights into the transformations that cities are undergoing. This raises two fundamental questions:

- Which interventions have taken COVID-19 contagion into account as a variable for their implementation in the territory?
- Which interventions are being/have been monitored to understand their results regarding COVID-19 contagion?

Thus, this research addresses the critical need to understand how cities have adapted to the COVID-19 crisis. The global changes triggered by COVID-19 have profoundly altered urban dynamics worldwide, presenting an opportunity to re-evaluate and innovate existing urban models.

2. Materials and Methods

This research is based on a literature review focused on urban transformations triggered by the COVID-19 pandemic. The selection of articles was primarily guided by their relevance to the topic, with an emphasis on studies addressing urban interventions and changes in public spaces in response to the pandemic.

The aim of this research is to provide a comprehensive review of practical cases in cities that have implemented urban planning interventions post-COVID-19 to contain the spread of infection and facilitate the continued use of urban spaces.

To achieve our goal, we considered scientific articles that documented applications already implemented in cities, recognising that the outcomes were not limited to the dissemination of scientific knowledge. The search was carried out on the Scopus and Web of Science (WoS) platforms due to their representativeness in multidisciplinary research, following a pre-defined query (Table 1).

Table 1. Queries used in the search on the Scopus and WOS scientific article platforms.

Scopus	TITLE-ABS-KEY ((“built environment” OR “urbanism” OR “urban planning” OR “territorial planning” OR “urban design”) AND (“COVID*”))
Web of Science	TS = ((“built environment” OR “urbanism” OR “urban planning” OR “territorial planning” OR “urban design”) AND (“COVID*”))

A simple query was used, made up of two groups of keywords: the first referring to the urban component of the interventions, allowing the team to collect all the studies whose interventions were applied in the urban context, and the second referring to the COVID-19 pandemic. The team decided to use a simple and comprehensive equation that would allow the different readers to manually select the studies that addressed the question we were looking for.

The period considered for this study was limited to scientific papers published from 1 January 2021 to 30 November 2023, and there were no geographical restrictions on the inclusion of selected articles. Although the pandemic emerged at the beginning of 2020, the selected studies were considered from the beginning of 2021. The team chose to start the literature review in 2021 to ensure that the results obtained referred to specific interventions that had already been implemented in the territory and that were motivated by the COVID-19 pandemic.

The inclusion criterion for the selection of scientific articles was that they addressed the application of interventions in a territory to promote a healthy space, considering COVID-19 pandemic issues. Articles were excluded because they did not fit the objective defined for this study (Figure 3).

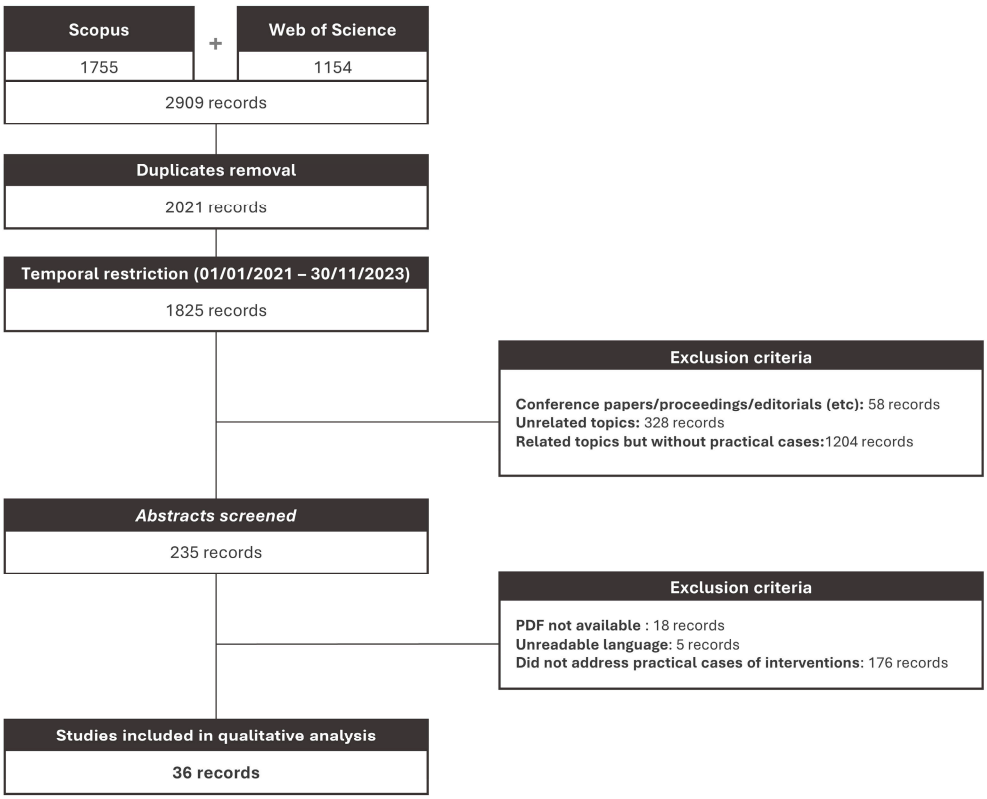

Figure 3. Selection scheme for the articles resulting from the literature review.

After removing duplicate articles, a first reading was carried out using titles, abstracts, and keyword screening, which enabled the articles resulting from the search to be selected and categorised, indicating the reason for their inclusion/exclusion. The reasons why the first studies were excluded were threefold: (a) conference papers, proceedings, and editorials; (b) studies on unrelated topics; and (c) studies on related topics but without practical cases of interventions.

Concerning the articles selected for the next phase, a full reading of each was carried out to decide which ones answered the starting question specifically. In this way, it was important to classify them in terms of (a) the geographical dimension under study (continent, country, and city(ies)), (b) the drivers for implementing the described interventions in the article (which and by whom), (c) the typology/approaches of the implemented interventions (typology and brief description), (d) the inclusion of COVID-19 contagion as a variable in the definition of the areas in which the interventions were applied, and (e) the intervention outcomes, whenever this information was available (Appendices A and B).

All the data collected were systematised in Endnote 20.4.1.16297 software as a way of organising the readings and better compiling them.

3. Results and Discussion

3.1. Study Characteristics

3.1.1. Sources of Selected Studies

In Figure 4, we can see the distribution of the selected studies by the journal or book in which they were published, as well as the nature of the studies. A descriptive analysis allowed us to gain a better understanding of the review results and the characteristics of the included studies.

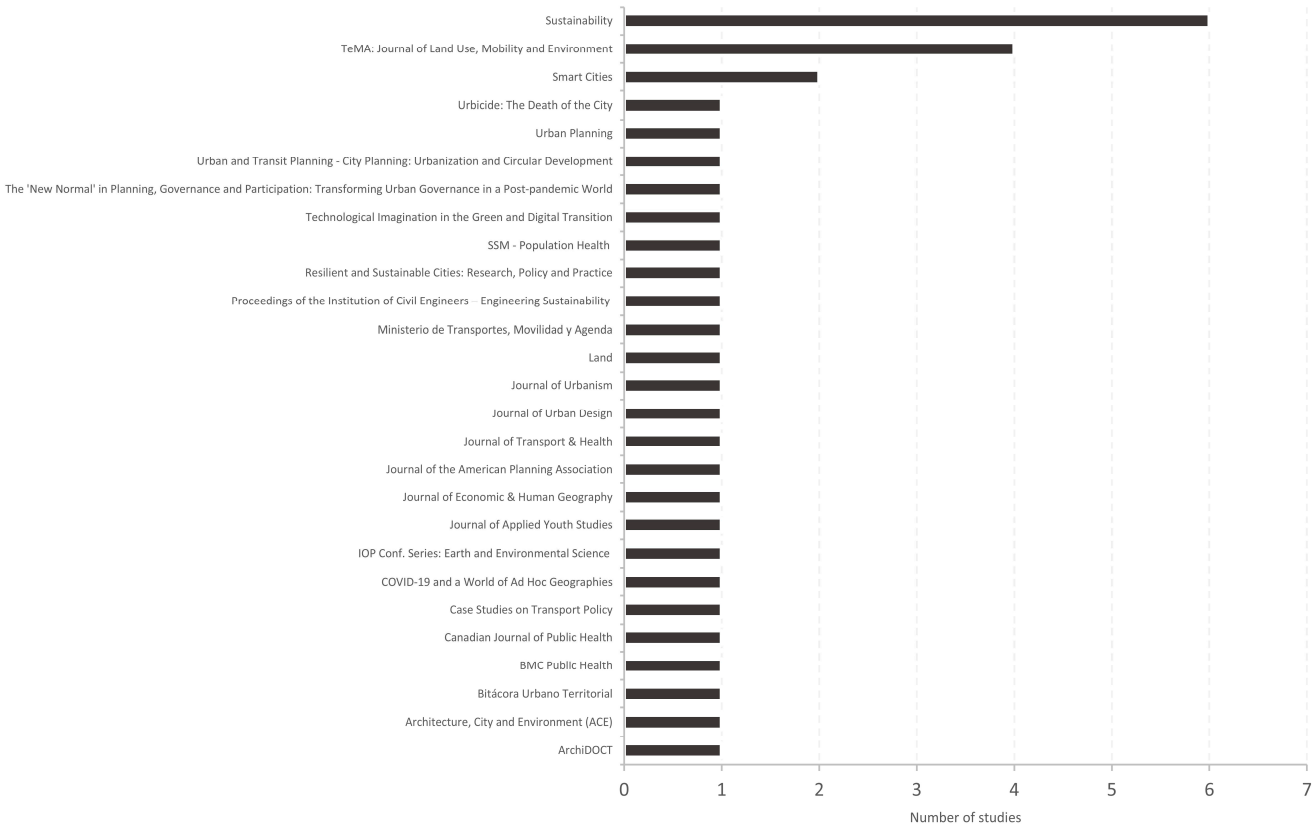

Figure 4. Sources of the selected studies.

The journal *Sustainability* had the highest number of selected studies, with a total of six publications [27–32]. This shows that sustainability was a key topic widely discussed in the studies eligible for this review. Next, *TeMA: Journal of Land Use, Mobility and Environment* stood out, with four articles [4,33–35], highlighting the relevance of land use, mobility, and environmental issues in research.

Other notable journals included *Smart Cities* [36,37], which contained two articles pointing to the growing importance of smart cities in the research on the topic brought up in this review. Several other journals, such as *Architecture, City and Environment* (ACE) [38], *Journal of the American Planning Association* [39], and *Urban Planning* [40], each had one article, indicating a wider distribution of research interests in the areas of urban planning and architecture.

In addition to journals, the review also included studies published in books, such as "Technological Imagination in the Green and Digital Transition" [41], "Resilient and Sustainable Cities: Research, Policy and Practice" [42], "Urbicide: The Death of the City" [43], "COVID-19 and a World of Ad Hoc Geographies" [44], "Urban and Transit Planning—City Planning: Urbanisation and Circular Development" [45], and "The 'New Normal' in Planning: Governance and Participation Transforming Urban Governance in a Post-Pandemic World" [46], with one publication each. This demonstrates the interdisciplinarity and diversity of the sources consulted, covering both periodicals and more extensive and specialised literature.

The distribution of the types of studies selected (Figure 5) also showed that most of the studies came from scientific journals, totalling 27 studies [4,27–40,47–57]. To a lesser extent, there were six studies classified as books (one) [42] and book chapters (five) [41,43–46]. This variation indicates that although scientific studies were the main source of information, there was also a significant contribution from other forms of publication, broadening the perspective of this review. Finally, only three of the selected results were from other types of publications, such as a conference paper [58], report [59], or study protocol [60].

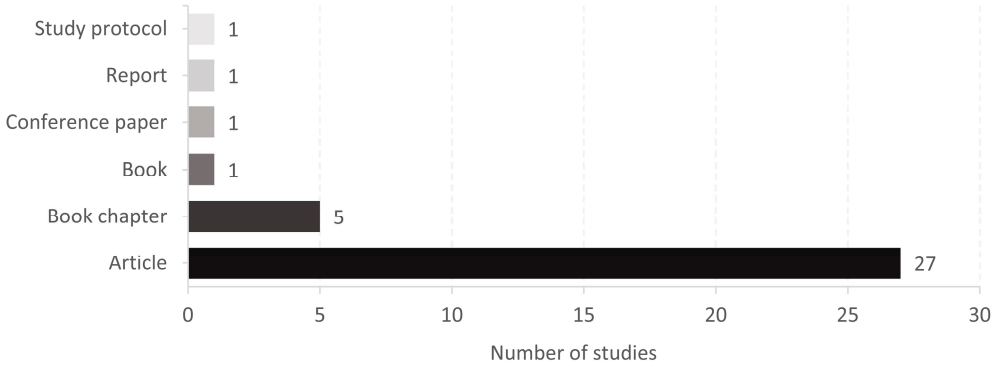

Figure 5. Typology of the selected studies.

3.1.2. Spatial Dimension and Intervention Drivers in the Selected Studies

As expected, all the chosen studies focused on actions in urban areas. However, there were also studies addressing various geographical scales within the urban environment. The analysis indicated that most of the interventions examined had a wide scope, covering multiple cities (58%) [4,28,29,31–35,37,40,41,45,47,48,51–53,55,57,58]. This suggests that many studies addressed urban problems and interventions that went beyond the boundaries of a single city, reflecting the search for scalable and replicable solutions in different urban contexts (Figure 6).

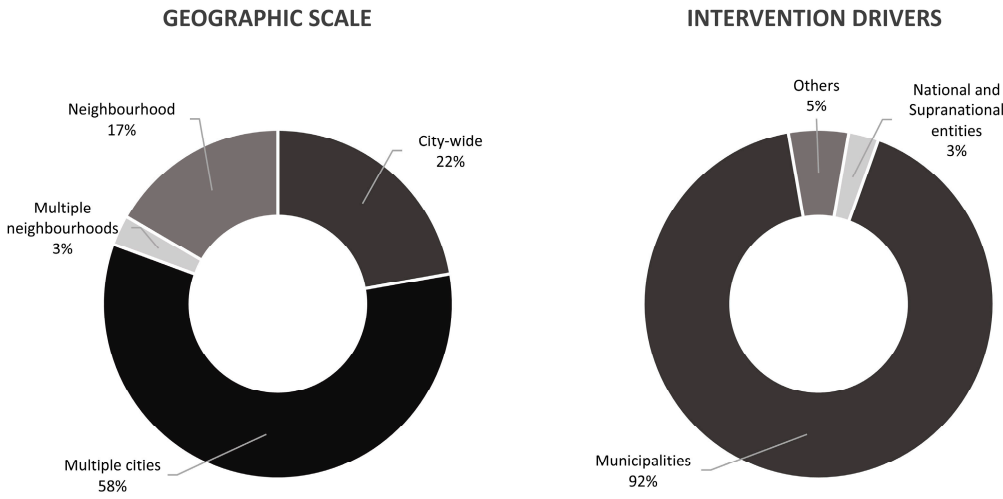

Figure 6. Spatial dimension and intervention drivers of the selected studies.

City-wide interventions made up 22% of the studies, indicating an approach focused on policies and strategies that affect the entire urban area [30,36,39,42,46,49,59,60]. In contrast, 17% of the studies focused on the neighbourhood level, suggesting a significant interest in micro-scale interventions that could offer detailed perceptions of specific dynamics and community impacts [27,43,50,54,56,61]. Finally, a small portion (3%), corresponding to one selected study, examined multiple neighbourhoods, exploring the interaction and variation between different areas within the same city [38].

Regarding intervention stakeholders, in most of the analysed interventions (91%), the driving force was the municipalities [4,27,28,30–40,42–53,55–61]. This underlines the central role of local authorities and the local scale in managing and implementing urban interventions that directly affect urban life and population health.

The European recovery plan and the "Italian Piano Nazionale di Ripresa e Resilienza" also appeared as drivers of intervention in 3% of the selected studies [41], indicating the impact of national and supranational entities and their funding impact on urban transformations. Finally, the population as a driver for urban changes accounted for 2% of

the interventions [54], suggesting a small but significant involvement in urban issues, which could drive new methods for transforming the territory. In addition to interventions led by population, universities were responsible for 3% of the interventions reported in the selected studies [29].

An analysis of the number of countries whose cities were mentioned in the selected studies revealed that the United States was the country with the highest number of reported interventions, totalling 11 interventions [4,28,33,34,37,44,50,51,53,57,58]. This reflects the emphasis on urban research and intervention policies within the American context, where urban issues such as sustainability, mobility, and land use have received considerable academic and practical attention (Figure 7).

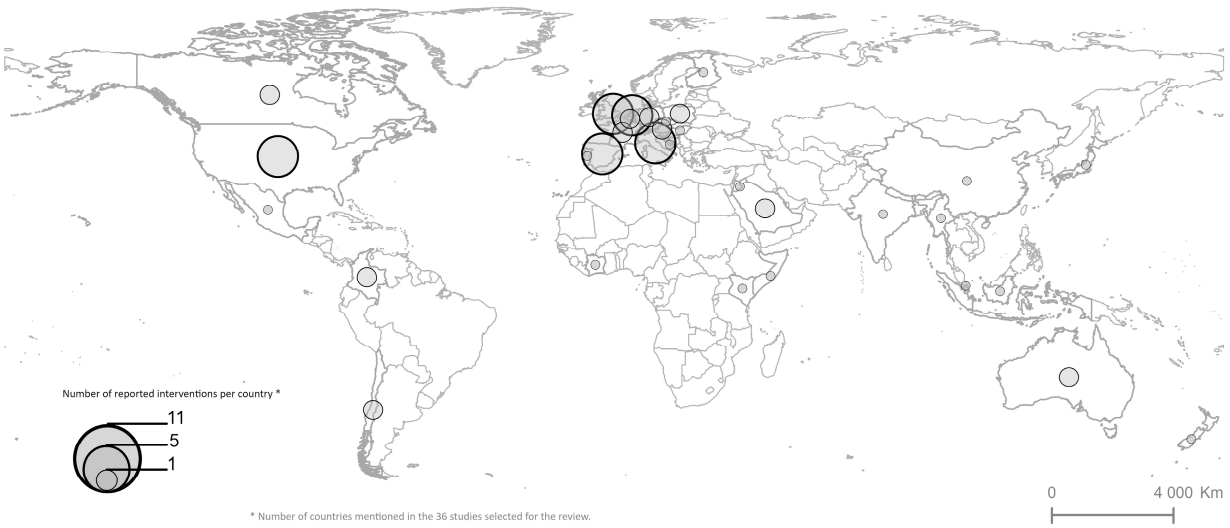

Figure 7. Number of countries whose cities were mentioned in the 36 studies selected for this review.

However, it was in Europe that there was a notable distribution of interventions in countries such as Spain, Italy, Germany, France, and the United Kingdom [4,28,29,32,33,35,37,41–43,45–49,55,57–59,61]. On the other hand, European countries such as Finland, Poland, and Portugal appeared with only one mention each, demonstrating that research into urban interventions is not just limited to the main European countries but also includes a wider range of geographical contexts [29–31].

In Asia, China and India appeared with 2–5 interventions reported, indicating their interest in urban issues in these countries, which face significant challenges due to rapid urbanisation [33,58]. It was interesting to note that on this topic, although China is one of the countries that has always been at the forefront of controlling the spread of COVID-19, it did not stand out when it came specifically to interventions applied on the ground, with physical applications. It appears that the focus in this country was on other strategies to contain the virus, which were not part of the focus of this research.

Japan, Indonesia, and Australia were also mentioned, suggesting particular attention to urban interventions in these highly developed and urbanised regions [37,39,54,56–58]. In addition, some countries in Latin America, Africa, and the Middle East appeared on the map, with one to two reported interventions [36,37,57,58,60].

3.2. Intervention Outcomes

For this analysis, it was important to understand how COVID-19 contagion was considered as a variable when choosing the areas where the interventions would be implemented. In this sense, the results show that only 6% of the studies considered contagion as a variable to define the areas of intervention, corresponding to two selected studies [27,58]. This indicates that the vast majority (94%) of interventions did not use COVID-19 contagion as a criterion or that this factor was not mentioned in the studies (Figure 8).

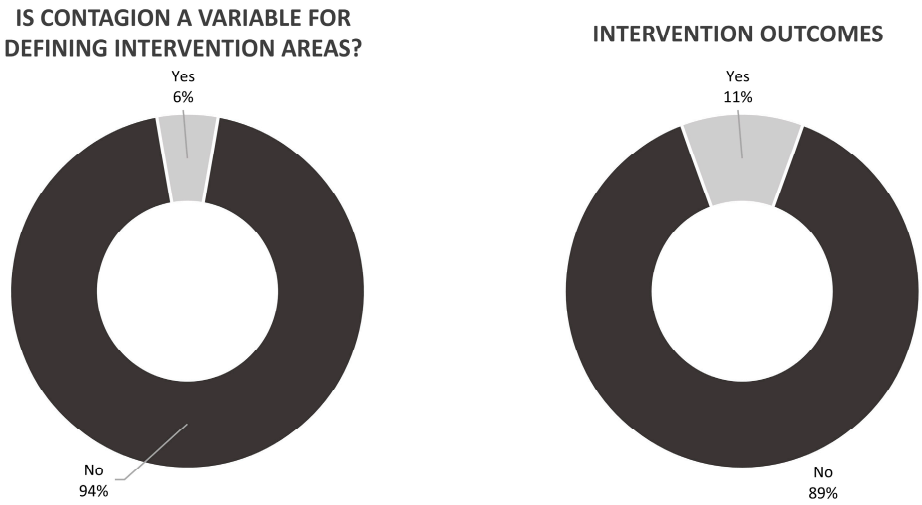

Figure 8. Variables considered in interventions and documented outcomes in selected studies.

Alnusairat et al. (2022) [27] focused on reconfiguring outdoor spaces on university campuses to improve health and wellbeing and reduce infections in open areas. Using analyses of user behaviour, environmental conditions, and preferences, the study proposed design solutions that maximised the potential of outdoor spaces to respond to future crises, highlighting the importance of safe and healthy environments.

Pradifta et al. (2021) [58] documented tactical urbanism interventions in several cities during the pandemic, aiming to improve public space and prevent the transmission of COVID-19. Measures included the creation of pop-up cycle lanes, physically distanced markets, and temporary outdoor dining areas, as well as signposts and markings to ensure social distancing in various urban areas.

Both studies demonstrate the importance of adapting urban spaces to mitigate contagion risks and promote public health, highlighting the need for innovative and practical solutions in urban planning.

Concerning the evaluation of the intervention outcomes, the selected studies revealed that 11% had already evaluated the results of the interventions carried out [29,30,53,55,60], while the majority (89%) had not yet done so. Evaluating results is crucial to understanding the effectiveness of interventions and guiding future urban policies and actions, but, given the short time frame, it would be expected that concrete results are not yet known. Among those that have not yet addressed the results, there was a willingness to continue to follow developments and, in the future, extend the research to an evaluation of their effectiveness.

Temporary interventions described by Aquilué et al. (2021) [29], such as mobile sound devices and modular furniture, were key to enabling people to enjoy the city in new ways, creating dynamic public spaces that promoted community wellbeing.

Similarly, Baeza et al. (2021) [60] observed that urban regeneration in Chile had a significant impact on residents' wellbeing. Initially, mobility restrictions helped with social distancing, but, over time, patterns of use of urban space changed, reflecting new ways of planning and enjoying weekends.

The importance of legal and administrative restrictions in urban mobility management was highlighted by Borowska-Stefańska et al. (2022) [30], who showed how these measures shaped the weekly distribution of traffic, underscoring the need for continuous adaptations to face future crises.

Kim (2022) [44] discussed the "Slow Streets" programme, which created temporary pedestrian spaces on residential streets in several US cities. Although it is difficult to assess its effectiveness due to a lack of data, the study emphasises the importance of including low-income communities in broader, more inclusive tactical urbanism strategies.

Finally, Rossitti et al. (2023) [55] analysed the economic impact of these interventions in Italy, revealing that measures such as street furniture and pedestrianisation influenced

property values in different ways. In some cities, there was a significant increase, while, in others, the appreciation was lower or even negative, demonstrating the complexity of the property market's responses to such changes.

3.3. Intervention Classification

Concerning implemented interventions in urban areas, with the motivation of promoting public health and adapting territories to the COVID-19 pandemic, it was possible to find many studies that addressed this issue (Figure 9). In the 36 studies selected, it was possible to group them into three main groups of interventions: (1) measures to boost the dynamism and safety of public spaces (22%), which corresponded to specific interventions such as urban installations, adaptations in the way public spaces were used, technological and emergency solutions, and informal urban recreation interventions; (2) infrastructure and resource management measures (39%), which comprised more comprehensive interventions, usually included in projects/programmes, and which included actions such as the expansion and promotion of community health infrastructures, innovations in urban infrastructure and mobility, and legal and administrative restrictions; and (3) sustainable urban development and post-COVID resilience interventions (39%), which constituted more complex urban strategies and included topics such as adapting public space and sustainable mobility and improving habitational conditions.

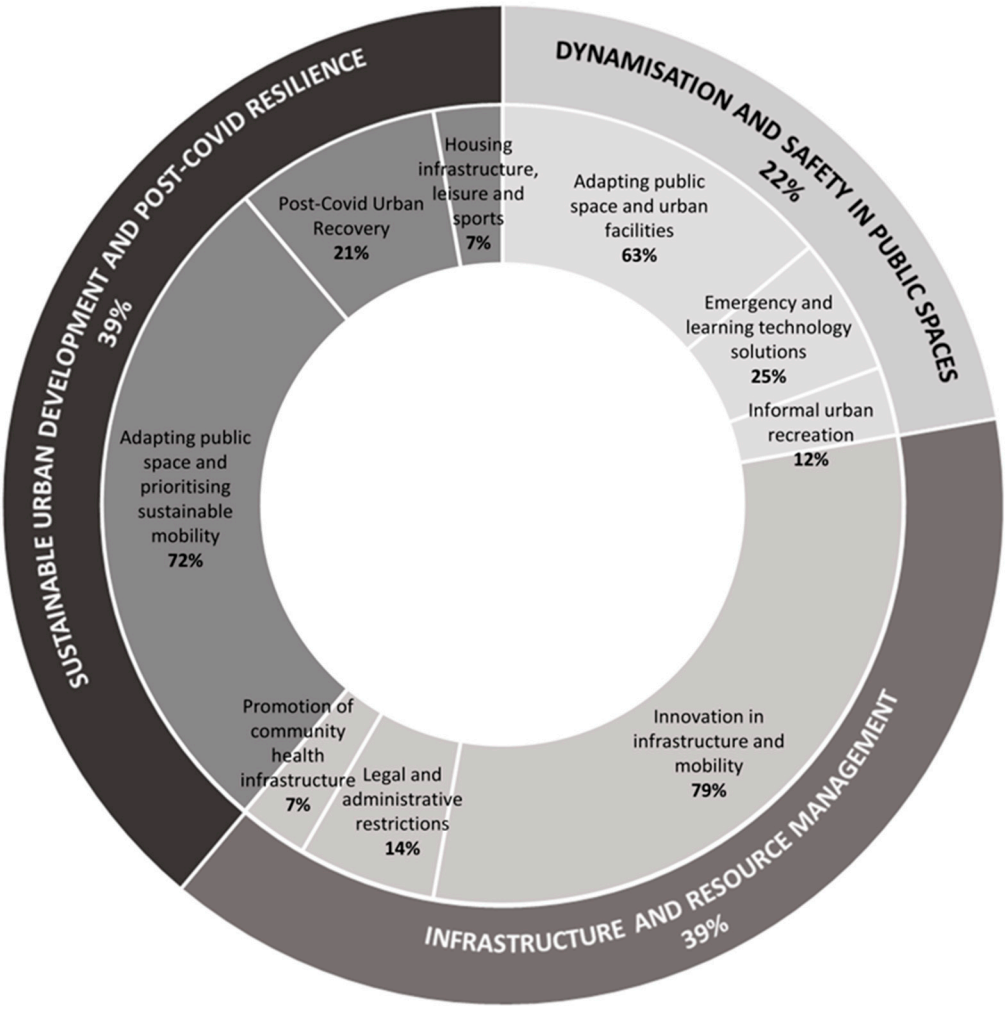

Figure 9. Categorisation of the groups and subgroups to which the urban interventions in the selected studies belonged.

The three classes of interventions varied in scale from specific, targeted measures to broader, more comprehensive structural changes, with each city's response shaped by its unique local conditions. These responses were influenced by a combination of spatial, cultural, social, and economic contexts, which played a crucial role in determining the nature and scope of the interventions implemented.

3.3.1. Dynamisation and Safety in Public Spaces

Looking at Figure 9, the group of interventions "Dynamisation and safety in public spaces" represented 22% of the total interventions reported in the selected studies. Within this group, the interventions were subdivided into three main categories: adaptation of public space and urban facilities (63%), technological emergency and learning solutions (25%), and informal urban recreation (13%). Each category reflected different approaches to revitalising and securing public spaces, particularly in response to the challenges posed by the COVID-19 pandemic.

Studies within this group highlighted diverse measures to improve public space safety and functionality, enhancing urban resilience and promoting community wellbeing during periods of crisis. Aina et al. (2023) [36], for example, highlighted the digitalisation and smartification of urban services in Mecca to contain the spread of the virus and strengthen urban resilience. This included the installation of telecom towers, Wi-Fi access points, smart devices such as health bracelets, and platforms for reporting hygiene problems. These technologies helped create a robust infrastructure to ensure public safety while maintaining essential urban functions.

On the other hand, Alnusairat et al. (2022) [27] focused on improving open spaces in universities, using student behaviour analysis and computer simulations to assess and optimise environmental conditions. Their interventions aimed to reduce infections and improve wellbeing by transforming university courtyards into "anti-virus" spaces, demonstrating a localised approach to adapting urban spaces to health risks.

Meanwhile, Aquilué et al. (2021) [29] and Fischer and Winters (2021) [52] focused on reconfiguring the use of streets and pavements, creating expanded and safe spaces for circulation and socialising. These interventions, such as widening pavements, creating shared streets, and closing certain streets entirely, aimed to promote physical distancing and encourage safe outdoor activities, thus safeguarding both public health and the social fabric of urban life during the pandemic.

Moreno et al. (2021) [37] popularised the concept of a "15-minute city", proposing the construction and expansion of cycling and pedestrian paths, alongside the creation of open-air markets and restaurants. These interventions were designed to adapt public spaces to ensure the safety and continuity of urban activities, even during periods of confinement and restrictions.

O'connell et al. (2022) [32] explored the design of new esplanades and open spaces in Barcelona and Milan, allowing people—especially residents—to maintain social interactions in a safe environment. Verhulst et al. (2023) [57] presented innovative urban experiments, such as "gathering circles" and safe streets initiatives, which aimed to foster physical distancing while still enabling the safe use of public spaces.

In addition, O'Keeffe (2021) [54] discussed informal urban recreation, focusing on the creation of "dirty jumps" during lockdown. These small ramps were initially built by young residents to practice sports such as BMX, but the municipality ended up introducing this intervention in its main parks. This intervention provided a way for youth to socialise and engage in physical activities in outdoor spaces, contributing to both mental and physical wellbeing during the isolation period.

3.3.2. Infrastructure and Resource Management

The infrastructure and resource management group represented 39% of the selected studies. It covered themes such as innovation in infrastructure and mobility (79%), legal and administrative restrictions (14%), and the promotion of community health infrastructure (7%). While these interventions were often acknowledged as essential for ensuring the sustainability and functionality of cities, it is critical to question whether these approaches truly addressed the long-term social and environmental impacts or if they were simply short-term fixes in response to pandemic crises. These strategies must be assessed for their true transformative power; they either reshape our urban infrastructure or merely maintain the status quo.

A central theme was the adaptation of public space to promote sustainable mobility and community health. Evenson et al. (2023) [50] focused on changing modes of transport to more sustainable alternatives during and after the pandemic. However, we must question whether these interventions truly address the underlying urban mobility inequalities, i.e., if they simply promote more affluent, green, healthier urban spaces or if it is also ensured that these sustainable mobility solutions are accessible to all populations, especially marginalised groups. Similarly, Harris and McCue (2023) and Hamman et al. (2023) [39,46] explored the implementation of temporary interventions such as the expansion of cycling paths and pavements to facilitate social distancing, which was reinforced by Herman and Drozda (2023) [31], who reported on the extension of these measures after the peak of the pandemic.

Another key aspect was how cities responded to the abrupt changes in the use of urban spaces. Kim et al. (2022) and Kim et al. (2023) [44,53] explored the impacts of temporary interventions on mobility patterns and the use of public space, with the implementation of the "Slow Streets" programme, while Krajnović et al. (2023) [38] highlighted the adaptation of school infrastructures to meet new social distancing needs.

The importance of legal and administrative restrictions during health crises was emphasised by studies by Borowska-Stefanska et al. (2022) and Firth et al. (2021) [30,51]. The implementation of regulations during a crisis raises questions about the power dynamics involved. It is essential to consider who holds the authority to influence the design of urban spaces in these situations and how such decisions impact marginalised groups. For instance, the adjustments made to retail trade and traffic patterns aiming to reduce contagion risks can often overlook the economic and social vulnerabilities faced by small businesses and low-income communities. Brambilla et al. (2023) [41] addressed the integration of community health facilities in urban areas to improve the response to public health emergencies.

The requalification of urban spaces also deserves deeper analysis. Ravagnan et al. (2022) and Schwimmer and Schaufler (2023) [35,45] highlighted how cities like Milan, Turin, and Bologna; the Spanish city of Barcelona; the German cities of Munich and Stuttgart; and the Swedish city of Stockholm responded to the crisis with urban transformation projects. Milan focused on reactivating public spaces, promoting outdoor activities, and implementing 30 km/h zones. Barcelona emphasised its dense urban model as effective for urban quality. Turin promoted sustainable, shared, and electric mobility. Bologna focused on promoting active mobility and reconfiguring spaces for traffic and car parking. On the other hand, "Schanigarten" was a temporary terrace café introduced in Munich during the COVID-19 pandemic to help restaurants comply with outdoor distance requirements. A "Connected Campus with emission-free mobility" project is underway, including smart amenities and space for student accommodation. "Pop-up bike lanes" were implemented in Stuttgart to revitalise public spaces and a "one-minute city" urban model is being tested in Stockholm to focus on residents' street-level concerns.

Finally, the interventions described by Nello-Deakin (2022) and Rositti et al. (2023) [55,61] offered important perceptions of the need for innovative resource management and infrastructure to improve urban resilience. However, we must ask whether tactical urbanism—which often involves temporary and low-cost interventions—can truly build long-term resilience. Interventions like the creation of carriageways, bus lanes, and bicycle lanes can be seen as positive, but it is still important to explore whether these initiatives are integrated into a comprehensive strategy that envisions a reimagined urban framework focused on resilience, equity, and sustainability.

3.3.3. Sustainable Urban Development and Post-COVID Resilience

The sustainable urban development and post-COVID resilience group, which also comprised 39% of the selected studies, focused on adapting public spaces and prioritising sustainable mobility (71%), ensuring post-COVID urban recovery (21%), and improving housing infrastructure and promoting leisure and sport (21%). These subdomains emphasised the need to build robust urban environments capable of withstanding future crises, yet often revealed a reactive rather than proactive approach to resilience, leaving open the question of whether these interventions adequately prepare cities for emerging global challenges.

Several studies emphasised the need for green spaces and adaptive infrastructures to foster resilience; for example, the work of Andreucci et al. (2021) [28] highlighted investment in post-pandemic urban recovery, emphasising the need for green spaces and adaptive infrastructure in cities such as London and Chicago. While green infrastructure is effective, research should explore how these spaces enhance social resilience beyond aesthetics and environmental benefits, particularly in densely populated urban areas. Ariano (2021) [47] mentioned the importance of reconfiguring spaces to meet the new demands of public health and wellbeing, yet stopped short of questioning whether these adjustments were sustainable long-term solutions or merely temporary fixes to a more complex problem of urban inequality.

Another central theme was the adaptation of cities to be more resilient and sustainable. Angiello (2021) [4,33,34], in a series of three studies, presented a set of urban interventions at different scales, from the redevelopment of neighbourhoods to the creation of car-free zones, as seen in Barcelona and Madrid. These transformations highlight the potential to promote healthier urban living, though a critical gap remains in understanding their socioeconomic impacts, especially for vulnerable communities who may not equally benefit from these changes.

Urban resilience was a key aspect addressed by Ashley et al. (2022) [48], who explored the BEGIN project, an inter-municipal collaboration to tackle common challenges and promote sustainable solutions. The study highlighted how the pandemic encouraged cooperation between cities to implement innovative urban adaptation strategies.

Adjustments to public space management were discussed by Delgado-Ruiz (2023) [43], who analysed the inclusion of temporary cycling lanes and the widening of pavements to ensure social distancing in Barcelona. While these interventions promoted safer spaces for pedestrians and cyclists, questions remain about the permanence of these changes and their integration into long-term urban planning frameworks. With no solid policies, there is a risk that these improvements may be reversed, undermining efforts to ensure sustainable mobility.

Cesaroli et al.'s study (2022) [42] emphasised the creation of a post-COVID city in Rome, Italy, where urban reconfiguration prioritised public health and sustainability. This post-COVID city was built in what they called an "antifragile" strategy, specifically for mobility and urban planning.

The studies by Baeza et al. (2021), Camerin (2022), and Stevens et al. (2023) enriched the discussion on urban adaptation in the post-COVID-19 context with distinct and complementary approaches. Baeza et al. (2021) [60] explored the revitalisation of degraded urban areas, showing how the pandemic has catalysed efforts to transform abandoned spaces into safe and attractive areas, promoting efficiency in land use.

Camerin (2022) [49] addressed the creation of post-COVID cities, highlighting the need to plan public spaces that prioritise health and sustainability. The reconfiguration of squares and parks was seen as a strategy to improve quality of life and increase urban resilience.

Stevens et al. (2023) [56] explored innovation with "playful parklets" in Melbourne suburbs. These parklets promoted inclusivity and community engagement through playful activities, raising questions about their scalability and impact in diverse cultural and urban settings. In this context, supplementary research is needed to explore how similar interventions adapt to different urban contexts, especially in high-density cities where public space is limited.

Also, the need to rethink urban planning was emphasised by Kurth (2022) and Pradifta et al. (2021) [40,58], who discussed building "15-min cities" and "smart cities", where all citizens' basic needs can be met within walking or cycling distance. This approach promoted sustainability and reduced dependence on motorised transport.

Finally, a study by Saravia-Madrigal (2021) [59] explored the implementation of green mobility policies during the pandemic, highlighting examples of adopted measures to reduce carbon emissions and improve urban air quality in the city of Valladolid. Although these interventions suggest a positive shift towards sustainable urban mobility, it is important to understand the long-term behavioural changes required to sustain these gains post-pandemic.

4. Final Remarks

This literature-based review has highlighted enduring questions, emphasising critical areas for future research. As cities struggle with the complexity of designing urban spaces that mitigate the spread of infectious diseases, a crucial challenge emerges in balancing effective public health interventions with the inherent limitation of existing infrastructures. There is a lack of research on the initial outcomes of post-COVID-19 interventions in urban areas, with many political decisions during and after the pandemic lacking scientific support. Additionally, most interventions have not been sufficiently monitored to understand their impacts on COVID-19 contagion. This absence of systematic monitoring and evaluation points to a need for more rigorous, data-driven assessments to ensure that interventions are both effective and adaptable to future health crises.

The selected studies also showed that, despite not having the possibility to completely block COVID-19 infections, it is possible to mitigate its effects and adapt the population to new occurrences of the same type. Given the impossibility of radically altering the spatial organisation of cities, particularly municipalities, many urban interventions focus on adapting existing spaces. These interventions aim to manage population density, mobility, and the distribution of services, while still ensuring the accessibility of open spaces for public use. However, the long-term efficacy of these adaptations is uncertain, prompting questions about their lasting impact on urban resilience. Further research is needed to explore the sustainability and scalability of these strategies. Thus, the urban population, including residents and visitors, will be central to finding effective solutions to adapt urban environments. Their decisions and perceptions of the spaces they use daily will play a critical role in this process.

Regarding the geographical distribution of the selected studies, they show a variety of different solutions currently being implemented. It is clear from the type of solutions that there are significant differences across different urban contexts. In other words, interventions in southwest Asia and the United Arab Emirates, for example, primarily focus on the smartification of cities, while European countries often follow broader guidelines from the European Commission, focusing on issues related to building space, the enhance-

ment of nature, tactical urbanism, temporary urbanism, and other targeted interventions to transform urban spaces. These regional trends highlight not only diverse responses to similar challenges but also the influence of political and economic factors in shaping intervention strategies.

Beyond these questions, cities exhibit significant variability, which has important implications for spatial interventions. Each city has a unique profile, emphasising the need to consider factors such as the spatial characteristics of open public spaces, social patterns, and local usage dynamics when analysing responses to COVID-19. Exploring these factors can provide important reflections on how cities can proactively design adaptable and resilient spaces to better prepare for future crises.

In this sense, the most pressing challenges in urbanism due to the emergence of COVID-19 and possible future pandemics include the need to adapt public spaces to accommodate growing populations while ensuring safety during outdoor activities. At the same time, there is an emphasis on promoting sustainable mobility by encouraging the use of sustainable modes of transport, such as walking, cycling, and public transport, to reduce reliance on private vehicles and minimise the contagion risk in confined spaces.

In terms of infrastructure and resource management, research highlights the importance of developing resilient and adaptable health systems, including improving hospital infrastructure, strengthening community health services, and ensuring equitable access to medical resources. These efforts must be regularly assessed and aligned with urban planning to prevent disparities in access and resilience across neighbourhoods, particularly those that are socioeconomically vulnerable.

Given the ongoing challenges, it is crucial to consider how sustainable connectivity can influence the adaptation of urban spaces. The COVID-19 pandemic has underscored the intricate ways infrastructure design can either exacerbate or alleviate issues related to public health, mobility, and spatial usage. This relationship between territory and health outcomes warrants in-depth exploration, emphasising the need for interdisciplinary approaches that bridge urban planning, public health, and environmental sustainability.

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Appendix A. Selected Studies and Their Main Characteristics

Author(s)	Title	Study Type	Journal/Book Title	Objectives	Geographic Scale	Country(ies)	City(ies)
Aina, Y. A. et al., 2023 [36]	Digitalization and Smartification of Urban Services to Enhance Urban Resilience in the Post-Pandemic Era: The Case of the Pilgrimage City of Makkah	Article	*Smart Cities*	The study identifies the relationship between human (social) behaviour and the different physical and environmental elements of spaces based on the relationship between the role of digitalisation and smartification in improving the resilience of pilgrimage towns such as the city of Mecca.	City-wide	Saudi Arabia	Makkah
Alnusairat, S. et al., 2022 [27]	Rethinking Outdoor Courtyard Spaces on University Campuses to Enhance Health and Wellbeing: The Anti-Virus Built Environment	Article	*Sustainability*	The study explores the relationship between human behaviour and physical/environmental elements of spaces using a mixed-methods approach. This includes user analysis, context analysis using space syntax and CFD, design solutions for virus transmission, and performance analysis of "anti-virus" courtyards.	Neighbourhood	Jordan	Al-Ahliyya Amman University (AAU)
Andreucci, M. B. et al., 2021 [28]	Exploring challenges and opportunities of biophilic urban design: Evidence from research and experimentation	Article	*Sustainability*	The research describes the main research and design paradigms that influence the way we understand the benefits of nature for different environments, including the workplace, the neighbourhood, and the city, and explains where biophilic design theory sits in this field.	Multiple cities	United Kingdom; USA	London; Chicago
Angiello, G., 2021 [33]	Toward greener and pandemic-proof cities? Policy responses to COVID-19 outbreak in four global cities	Article	*TeMA: Journal of Land Use, Mobility and Environment*	The study aims to present recent advances in relevant topics that are at the root of the challenges that cities have to face.	Multiple cities	USA; China; France; Singapore	New York; Paris; Beijing; Singapore
Angiello, G., 2021 [34]	Toward greener and pandemic-proof cities: North American cities policy responses to COVID-19 outbreak	Article	*TeMA: Journal of Land Use, Mobility and Environment*	The study aims to present recent advances in relevant topics that are at the root of the challenges that cities have to face.	Multiple cities	USA; Mexico; Canada	New York; Mexico City; Montreal
Angiello, G., 2021 [4]	Toward greener and pandemic-proof cities: policy responses to COVID-19 outbreak in four European cities	Article	*TeMA: Journal of Land Use, Mobility and Environment*	The study aims to present recent advances in relevant topics that are at the root of the challenges that cities have to face.	Multiple cities	Spain; United Kingdom; Italy; Belgium	Madrid; London; Milan; Brussels
Aquilué, I. et al., 2021 [29]	A methodology for assessing the impact of living labs on urban design: The case of the furnish project	Article	*Sustainability*	The study aims to assess the impact of urban living labs (ULLS) on urban design by evaluating the results of applications in pilot cities.	Multiple cities	Portugal; Finland; Hungary; Italy; Spain	Guimaraes; Espoo; Budapest; Barcelona
Ariano, A., 2021 [47]	COVID-19 As A Catalyst For Collaborative City-Making: From Emergency To Praxis	Article	*ArchiDOCT*	The article aims to present good practices already implemented by various cities around the world to adapt the territory and the population to a more collaborative city.	Multiple cities	USA; Italy; Spain; the Netherlands	New York; STEEM Park; Milan; Barcelona; Luchtsingel; Rotterdam
Ashley, R. M. et al., 2022 [48]	The benefits of nature-based systems in a and uncertain world	Article	*Proceedings of the Institution of Civil Engineers—Engineering Sustainability*	Based on the European BEGIN project, this article aims to show the importance of introducing NBS for the development of cities and their importance at various levels.	Multiple cities	United Kingdom	Kent; Bradford

Author(s)	Title	Study Type	Journal/Book Title	Objectives	Geographic Scale	Country(ies)	City(ies)
Baeza, F. et al., 2021 [60]	The Regeneracion Urbana, Calidad de Vida y Salud—RUCAS project: a Chilean multi-methods study to evaluate the impact of urban regeneration on resident health and wellbeing	Study protocol	*BMC Public Health*	A longitudinal study aimed at assessing the impact on health and wellbeing of interventions carried out as part of the urban regeneration programme in Chile. The interventions are mentioned but are not the focus of the article.	City-wide	Chile	N/A
Borowska-Stefanska, M. et al., 2022 [30]	Spatiotemporal Changeability of the Load of the Urban Road Transport System under Permanent and Short-Term Legal and Administrative Retail Restrictions	Article	*Sustainability*	The main aim of the article is to identify the spatio-temporal variability of the urban road transport system's load under permanent and short-term legal and administrative retail restrictions and determine its spatial and temporal nature, using the example of Łód'z (a large city in the centre of Poland) in the period from 2018 to 2021.	City-wide	Poland	Łód'z
Brambilla, A. et al., 2023 [41]	A New Generation of Territorial Healthcare Infrastructures After COVID-19	Book chapter	*Technological Imagination in the Green and Digital Transition*	The study aims to investigate the spatial, functional, technological, and organisational needs of new community healthcare centres and hospitals in Italy as part of the PNRR. It maps regional requirements, reviews guidelines, collects data, and develops a comparison matrix.	Multiple cities	Italy	14 city regions
Camerin, F., 2022 [49]	Regenerar el antiguo barrio industrial del Poblenou (Barcelona)	Article	*Bitácora Urbano Territorial*	The article aims to assess whether the "*Superilla Barcelona*" plan measures can improve the post-COVID-19 neighbourhood of Poblenou, using OECD indicators for inclusive, green, and well-governed cities. The study highlights the change of focus in the urban regeneration of Poblenou, driven by the pandemic, with the creation of healthier public spaces and cycle paths.	City-wide	Spain	Barcelona
Cerasoli, M. et al., 2022 [42]	The theoretical grid: An antifragile strategy for Rome post-COVID mobility	Book	*Resilient and Sustainable Cities: Research, Policy and Practice*	The essay recommends an "antifragile" strategy for post-COVID mobility in Rome and other European cities, incorporating urban planning and mobility, based on research by Roma Tre University and Sapienza University of Rome.	City-wide	Italy	Rome
Delgado-Ruiz, M., 2023 [43]	The Ideology of Public Space and the New Urban Hygienism: Tactical Urbanism in Times of Pandemic	Book chapter	*Urbicide: The Death of the City*	The aim of the study is to analyse how tactical urbanism gained expression after being adopted as a temporary measure in Barcelona at the time of the COVID-19 lockdown and which became a permanent measure adopted by other cities, transforming the perception and use of open public space.	Neighbourhood	Spain	Barcelona
Evenson, K. R. et al., 2023 [50]	Mixed method assessment of built environment and policy responses to the COVID-19 pandemic by United States municipalities focusing on walking and bicycling actions	Article	*Journal of Transport & Health*	The aim of the study is to systematically describe the municipal response to the pandemic at the community level through environmental and political changes that may have had an impact on walking and cycling.	Neighbourhood	USA	N/A

Author(s)	Title	Study Type	Journal/Book Title	Objectives	Geographic Scale	Country(ies)	City(ies)
Firth, C. L. et al., 2021 [51]	Not quite a block party: COVID-19 street reallocation programs in Seattle, WA and Vancouver, BC	Article	*SSM—Population Health*	The project analyses street reallocation programmes in Seattle WA and Vancouver BC. They seek to identify socio-spatial differences in access to street reallocations (e.g., how street reallocations are distributed across neighbourhoods) as well as how reallocations relate to existing infrastructure (e.g., are they extensions of existing cycling networks or new mobility corridors) in each city and contrast the findings between Vancouver and Seattle.	Multiple cities	USA	Seattle; Vancouver
Fischer, J., and Winters, M., 2021 [52]	COVID-19 street reallocation in mid-sized Canadian cities: socio-spatial equity patterns	Article	*Canadian Journal of Public Health*	The research seeks to understand which street relocation interventions have been implemented and what the patterns of socio-spatial equity have been in 3 medium-sized cities in Canada: Victoria (British Columbia), Kelowna (British Columbia), and Halifax (Nova Scotia).	Multiple cities	Canada	Victoria (British Columbia); Kelowna (British Columbia); Halifax (Nova Scotia)
Hamman, P. et al., 2023 [46]	Pandemic Cycling Urbanism in French Intermediate Cities: A Singular Episode or a Shift to a "New Normal"?	Book chapter	*The 'New Normal' in Planning, Governance and Participation*	The study aims to examine the durability of urban responses and the innovations designed to deal with the health crisis caused by COVID-19 and their possible impacts in the post-pandemic future as "normal" practices in city building.	City-wide	France	Mulhouse
Harris. M., and McCue, P., 2023 [39]	Pop-Up Cycleways: How a COVID-19 "Policy Window" Changed the Relationship Between Urban Planning, Transport, and Health in Sydney, Australia	Article	*Journal of the American Planning Association*	Drawing on Kingdon's multiple flows theory, this study examines the policy development process that led to the rapid installation of pop-up cycle lanes in Sydney (Australia) in response to COVID-19.	City-wide	Australia	Sidney
Herman, K., and Drozda, Ł., 2021 [31]	Green infrastructure in the time of social distancing: Urban policy and the tactical pandemic urbanism	Article	*Sustainability*	The study discusses and compares the operation and use of two parks located in Wellington, New Zealand, and Warsaw, Poland, adopting "pandemic urban ethnography", an approach that includes autoethnography, interviews with users, non-participant observation, and social media content analysis.	Multiple cities	New Zealand; Poland	Wellington; Warsaw
Kim, J., 2022 [53]	COVID-19's impact on local planning and urban design practice: focusing on tactical urbanism and the public realm with respect to low income communities	Article	*Journal of Urbanism*	The article aims to analyse the effects of local planning in response to COVID-19, with a focus on the use of tactical urbanism by planners to improve public health.	Multiple cities	USA	Los Angeles; Oakland; San Francisco; Seattle; Portland; Denver; Chicago; Detroit; New York; Minneapolis
Kim, J., 2023 [44]	Impact of COVID-19 on Local Planning Practices: Focusing on Tactical Urbanism, Slow Streets and Low-Income Communities in Oakland, Los Angeles, San Francisco, Denver, Chicago, and New York	Book chapter	*COVID-19 and a World of Ad Hoc Geographies*	The study aims to investigate whether tactical urbanism strategies, such as "Slow Streets", "Open Streets", "Safe Streets", and "Essential Places", led by local government entities in US cities, can improve the health of disadvantaged communities during the COVID-19 pandemic. The study evaluates the effectiveness of these programmes in promoting health in low-income communities and identifies potential limitations and areas for improvement in urban planning.	Multiple cities	USA	Oakland; Los Angeles; San Francisco; Denver; Chicago; New York

Author(s)	Title	Study Type	Journal/Book Title	Objectives	Geographic Scale	Country(ies)	City(ies)
Krajnović, M. et al., 2023 [38]	School Outdoor Spaces as Urban Public Space Activators	Article	*Architecture, City and Environment* (ACE)	The article presents three examples of interaction between the outdoor spaces of primary schools and urban public spaces. This interaction is a viable future trend in school design and urban planning, considering the reduction in accessible community areas, to bring education back to its origins in nature and urban public spaces.	Multiple neighbourhoods	Croatia	Žnjan Pazdigrad School, Split; Sports Hall and Fran Krsto Frankopan School, Krk; Ljudevit Gaj School, Krapina
Kurth, D., 2022 [40]	City Models and Preventive Planning Strategies for Resilient Cities in Germany	Article	*Urban Planning*	The study analyses how Germany's urban development strategies have adopted a holistic vision that looks not only at environmental issues but also at building a city that is resilient to new types of disasters that may occur in the urban environment.	Multiple cities	Netherlands; Austria	Rotterdam; Vienna
Moreno, C. et al., 2021 [37]	Introducing the "15-min city": Sustainability, resilience and place identity in future post-pandemic cities	Article	*Smart Cities*	With the concept gaining ground in the popular media and its subsequent adoption at a political level in many cities of varying scale and geography, this document sets out to present the concept, its origins and intentions, and future directions.	Multiple cities	Germany; Austria; Netherlands; Italy; Scotland; USA; Colombia; Canada; Australia	Berlin; Vienna; Rotterdam; Turin; Edinburgh; Oakland; Philadelphia; Denver; Minneapolis; Dallas; Seattle; Bogotá; Vancouver; Calgary
Nello-Deakin, S., 2022 [61]	Exploring traffic evaporation: Findings from tactical urbanism interventions in Barcelona	Article	*Case Studies on Transport Policy*	The article explores the relative levels of traffic evaporation following the implementation of multiple tactical urbanism interventions on 11 streets in Barcelona in the context of the COVID-19 pandemic.	Neighbourhood	Spain	Barcelona (11 streets)
O'connell, E. M. et al., 2022 [32]	Outdoor Terraces in Barcelona and Milan: Configuration of New Spaces for Social Interaction	Article	*Sustainability*	The article explores how the number of terraces and open spaces for socialising near restaurants and similar establishments has increased, especially since the COVID-19 pandemic, using the cities of Barcelona and Milan as a case study.	Multiple cities	Spain; Italy	Barcelona; Milan
O'Keeffe, P., 2022 [54]	Young Peoples' Construction of DIY Dirt Jumps in Melbourne, Australia, Throughout the COVID-19 Lockdowns	Article	*Journal of Applied Youth Studies*	The article analyses the unstructured/informal production of "dirty jumps" in public spaces by young people in Melbourne, based on the council's responses to this "movement".	Neighbourhood	Australia	Melbourne
Pradifta, F. S. et al., 2021 [58]	The Application of Tactical Urbanism in Public Space on COVID-19 Transmission Prevention	Conference paper	*IOP Conf. Series: Earth and Environmental Science*	The study seeks to analyse the application of tactical urbanism to combat the transmission of COVID-19 in public spaces, using a case study and a systematic literature review of cases applied around the world.	Multiple cities	Indonesia; Saudi Arabia; India; Myanmar; Italy; Czech Republic; the Netherlands; Belgium; Germany; France; USA; Colombia; Australia; Somalia; Kenya	Bandung; Salatiga; Bandar Lampung; Jakarta; Mecca; New Delhi; Kalaw; Vicchio; Brno; London; Birmingham; Amsterdam; Knokke-Heist; Berlin; Brussels; Bordeaux; Dallas; New York; Tampa; Charlotte; Fort Lauderdale; Las Vegas; San Francisco; Austin; Bogotá; Sydney; Mogadishu; Nairobi

Author(s)	Title	Study Type	Journal/Book Title	Objectives	Geographic Scale	Country(ies)	City(ies)
Ravagnan, C. et al., 2022 [35]	Post-COVID cities and mobility A proposal for an antifragile strategy in Rome	Article	*TeMA: Journal of Land Use, Mobility and Environment*	The research, carried out as part of a collaboration between Sapienza University of Rome and Roma Tre University, aims to propose an "anti-fragile" strategy for "post-COVID Rome", adaptable to other European city contexts, based on an integrated approach to urban planning and mobility.	Multiple cities	Spain; Italy	Barcelona; Milan; Bologna; Turin
Rossitti, M. et al., 2023 [55]	Tactical Urbanism Interventions for the Urban Environment: Which Economic Impacts?	Article	*Land*	The study looks at tactical urbanism interventions in Italy and assesses their economic impacts, particularly concerning property market values.	Multiple cities	Italy	Cinisello Balsamo; Reggio Emilia; Bologna; Massa Carrara; Rome; Bari; Taranto; Rosarno; Sassari (2)
Saravia-Madrigal, M., 2021 [59]	Valladolid 2020 urban master plan, on the sunny side of the street	Report	Ministerio de Transportes, Movilidad y Agenda	The document is an analysis of Valladolid's 2020 General Urban Planning Plan (PGOU). It emphasises building a friendly and resilient city, addressing urban challenges including the COVID-19 pandemic. The plan also focuses on land classification, public participation, and urban equity. Additionally, it discusses the importance of maintaining central institutions and diversifying the local economy away from the automotive sector.	City-wide	Spain	Valladolid
Schwimmer, E., and Schaufler, C., 2023 [45]	Towards Adaptive Planning of Urban Spaces in the Context of a New Agile Urbanism	Book chapter	*Urban and Transit Planning—City Planning: Urbanization and Circular Development*	The study investigates how municipal planning departments can react to short-term changes in the urban flow of people. It explores effective processes for adapting the allocation of urban space. It proposes adjustments to planning procedures to deal with the rapid and variable use of urban spaces.	Multiple cities	Germany	Munich; Stuttgart; Malmo; Gothenburg; Umea
Stevens, Q. et al., 2023 [56]	Playful, portable, pliable interventions into street spaces: deploying a 'playful parklet' across Melbourne's suburbs	Article	*Journal of Urban Design*	The article examines the evolution of the design, programming, approval process, and reception of a "playful parklet", available for free public use, which was transformed and relocated between four urban contexts in Melbourne.	Neighbourhood	Australia	Melbourne
Verhulst, L. et al., 2023 [57]	Street Experiments and COVID-19: Challenges, Responses and Systemic Change	Article	*Journal of Economic andHuman Geography*	The document explores urban case studies and demonstrates how pandemic-induced street experiences provide a solution to specific challenges to mobility and public space.	Multiple cities	Belgium; USA; Chile; the Netherlands; Japan; Germany; Ivory Coast; United Kingdom	Ghent; New York; Portland; Chillán; the Netherlands; Tokyo; Munich; Abidjan; Brussels; London

Appendix B. Selected Studies and Their Reported Intervention Characteristics

Author(s)	Intervention Timing	Intervention Drivers	Intervention Purpose	Intervention Domain	Intervention Subdomain	Intervention Description	Contagion as a Variable?	Intervention Outcomes
Aina, Y. A. et al., 2023 [36]	During/After	Municipality(ies)	Containing and minimising the spread of the COVID-19 virus and strengthening urban resilience	Dynamisation and Safety in Public Spaces	Emergency and Learning Technology Solutions	Smart city development during the pandemic: More than 5900 telecom towers and 11,000 Wi-Fi access points have been installed in Mecca and Madina. There has been a 41 per cent increase in deploying 5G towers in these cities, which now have more than 2600 towers. Also, 25 hospitals have been equipped with 5000 smart beds and a medical team of 1141 people to provide physical and virtual healthcare services in the two holy cities. In addition, more than 140 mobile clinics, 142 health centres, and 86 medical teams have also been made available on the ground at strategic locations in the sacred sites. Digitalisation and smartification of urban services: Technological equipment such as smart robots, thermal cameras, smart bracelets, virtual reality devices, and platforms for reporting hygiene problems in the pilgrimage area, among others, have been implemented. Improving Mecca's resilience through smartification: Technology for crowd management includes health monitoring, digital fencing, smart wristbands, early health alerts, and accurate location data. The Saudi green initiative focuses on smart mobility projects to reduce greenhouse gas emissions and offers visas for pilgrims to visit other Saudi cities for social networking and tourism. Adaptable and flexible technologies, such as the Haramain railway, Mecca metro, Mecca bus project, and the Development Authority, maintain connectivity between the holy sites.	No	No
Alnusairat, S. et al., 2022 [27]	After	Municipality(ies)	Enhancing health and reducing infections in open spaces such as university campuses to better respond to future crises.	Dynamisation and Safety in Public Spaces	Emergency and Learning Technology Solutions	The text discusses the development of a user analysis layer to study student needs and behaviours, using space syntax and computational fluid dynamics to explore physical and environmental conditions. Design solutions were developed by considering social, physical, and environmental factors, along with performance and preference analysis to test alternatives and capture student preferences.	Yes	No

Author(s)	Intervention Timing	Intervention Drivers	Intervention Purpose	Intervention Domain	Intervention Subdomain	Intervention Description	Contagion as a Variable?	Intervention Outcomes
Andreucci, M. B. et al., 2021 [28]	Before/After	Municipality(ies)	Theoretical and practical review of applications of biophilic urbanism in cities such as London and Chicago	Sustainable Urban Development and Post-COVID Resilience	Adapting Public Space and Prioritising Sustainable Mobility	Creating sustainable urban environments involves integrating green elements at various scales, such as green roofs and facades at the building level, street trees and pocket parks at the block level, and city parks and urban agriculture at the city level. Examples of these applications include the Queen Elizabeth Olympic Park, Greenwich Millennium Village, the Barbican, and Mudchute Park and Farm in London.	No	No
Angiello, G., 2021 [33]	After	Municipality(ies)	Investment in post-COVID-19 recovery plans	Sustainable Urban Development and Post-COVID Resilience	Adapting Public Space and Prioritising Sustainable Mobility	New York City expanded pedestrian crossings, created car-free streets, extended bike lanes, and allowed bars, restaurants, and cafes to expand onto pavements. Paris introduced the concept of a "15-minute city" and implemented urban design measures. Beijing focused on waste management, building technologies, spatial planning, building design, public facilities planning, and self-sufficient urban development. Singapore emphasised green building, transport, renewable energy, land use, public facilities, and economic development measures.	No	No
Angiello, G., 2021 [34]	After	Municipality(ies)	Investment in post-COVID-19 recovery plans	Sustainable Urban Development and Post-COVID Resilience	Post-COVID Urban Recovery	New York expanded pedestrian crossings and closed streets for more pedestrian space, added 83 miles of car-free streets, extended bike lanes, and allowed bars and restaurants to expand outdoor seating. In Mexico, the government plans to invest in infrastructure, social housing, public transport, and urban planning. Measures include housing projects, consultations with residents, and improving public transport and cycling infrastructure. In Montreal, the recovery plan focuses on stabilising the economy and reinventing economic development. Actions include occupying vacant spaces, creating a carbon-free urban bicycle delivery service, and investing in urban regeneration and public transport projects.	No	No

Author(s)	Intervention Timing	Intervention Drivers	Intervention Purpose	Intervention Domain	Intervention Subdomain	Intervention Description	Contagion as a Variable?	Intervention Outcomes
Angiello, G., 2021 [4]	After	Municipality(ies)	Investment in post-COVID-19 recovery plans	Sustainable Urban Development and Post-COVID Resilience	Post-COVID Urban Recovery	Madrid, London, Milan, and Brussels have all implemented ambitious urban development plans aimed at improving the quality of life for residents and promoting sustainable growth. These plans include initiatives such as planting trees, promoting sustainable mobility, creating pedestrian areas, and supporting economic recovery.	No	No
Aquilué, I. et al. 2021 [29]	During/After	Public and private organisations; universities	Understand how people enjoy the city after COVID-19	Dynamisation and Safety in Public Spaces	Adapting Public Space and Urban Facilities	Mobile autonomous spatial devices (megaphone, designed to amplify the sound of drums); multipurpose object (comfortable seat with an integrated audio system); installation of digitally manufactured furniture sets and graphics; modular street furniture system; ephemeral and itinerant architectural device; prototype as a system rather than a specific object; modular and adaptable system of reusable and rapidly deployable urban elements.	No	Yes
Ariano, A., 2021 [47]	During/After	Municipality(ies)	Making cities more resilient and adopting practices that involve the population throughout the process to build more collaborative cities	Sustainable Urban Development and Post-COVID Resilience	Adapting Public Space and Prioritising Sustainable Mobility	- Social distancing measures—New York; - Redistribution of road space for pedestrians and cyclists—Milan, Italy (hyperlocal urbanism); - Redistribution of road space for pedestrians—Barcelona, Spain (hyperlocal urbanism); - Revitalising the centre of Rotterdam by building a bridge linking the north to the centre. The bridge was built by the inhabitants themselves, who contributed with materials they had bought. The construction of this bridge gave rise to three very important public spaces: Dakakker (urban farming roof); Delftsehof (nightlife area); Popenburg Park, with a vegetable garden—Luchtsingel Bridge, Rotterdam; - STEEM Park, New York: a park founded on the STEEM platform where users support the authors of ideas through Likes and Shares, which give them financial support. This project was funded by two designers and co-founders of SNDBX.	No	No

Author(s)	Intervention Timing	Intervention Drivers	Intervention Purpose	Intervention Domain	Intervention Subdomain	Intervention Description	Contagion as a Variable?	Intervention Outcomes
Ashley, R. M. et al., 2022 [48]	After	Municipality(ies)	Adding value to cities and qualifying their growth by introducing NBS, based on the BEGIN project's assumptions	Sustainable Urban Development and Post-COVID Resilience	Adapting Public Space and Prioritising Sustainable Mobility	Kent, Bell Road, Sittingbourne: The drainage of 2.1 hectares of motorways and private footpaths for underground infiltration storage. Kent, George V Park, Margate: The drainage of 1.6 hectares of local motorways for bio-swales and infiltration drainage. Motorway realignment of the Bradford Canal Road corridor, which involves numerous sustainable urban drainage systems (Suds) and the decommissioning of Bradford Beck.	No	No
Baeza, F. et al., 2021 [60]	Before/After	Municipality(ies)	Evaluate the impact of interventions on the health and wellbeing of the population	Sustainable Urban Development and Post-COVID Resilience	Housing Infrastructure, Leisure, and Sports	Housing area (m^2) before the intervention; housing area (m^2) after the intervention; thermal and acoustic insulation; roof improvements; final location of the dwelling; improvement or installation of public services (sanitation, electricity); demolished dwellings (as a % of existing dwellings before the intervention); new public leisure spaces (green areas, parks); sports facilities (sports fields, playgrounds); afforestation of streets and parks; improvement of roads (streets, pavements); improvement of existing street lighting; new bus stop; new community centres; participatory social diagnoses; revitalisation of community organisations.	No	From the questionnaires applied, it emerged that the neighbourhoods studied had worse conditions than the Chilean population.
Borowska-Stefanska, M. et al., 2022 [30]	Before/During	Municipality(ies)	To understand the changes in the load of the transport system following the application of permanent and short-term legal and administrative restrictions on the retail trade	Infrastructure and Resource Management	Legal and Administrative Restrictions	Regulations aimed at ensuring the stability and fairness of the retail trade industry, including both long-term and short-term restrictions.	No	The government policy initially limited virus spread by facilitating social distancing, but subsequent waves showed weaker impacts. Long-term observations proved that Sunday retail restrictions and pandemic measures shaped traffic patterns.

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Brambilla, A. et al., 2023 [41]	After	European recovery plan and "Italian Piano Nazionale di Ripresa e Resilienza"	Strengthening proximity networks, equipment, and telemedicine for territorial healthcare	Infrastructure and Resource Management	Promotion of Community Health Infrastructure	Community homes are multi-purpose facilities, easily recognisable and accessible, that allow patients to come into contact with all the health, social, and sanitary services offered by the SNS on a territorial scale. Community hospitals are territorial intermediate care units for short-term stays that aim to improve the quality and appropriateness of care, avoiding unnecessary hospitalisations and undue access to hospitals. They are intended for patients who need low-intensity clinical interventions and continuous nursing care and supervision that cannot be provided at home.	No	No
Camerin, F., 2022 [49]	After	Municipality(ies)	Creating a post-COVID city	Sustainable Urban Development and Post-COVID Resilience	Adapting Public Space and Prioritising Sustainable Mobility	*Passeig de Mar Bella*: Redevelopment of the coastline and link to *Besòs* area; *Avenida Diagonal*; "*Protegemos las escuelas*": Traffic calming, improved access to schools, and green spaces; "22@, *más inclusivo y sostenible*": Consolidating existing fabric and transforming areas for the mixed city with environmental quality; "*Balcó Gastronòmic del Puerto Olímpico*": Revitalisation of Port Olímpico into a new market; "*Carriles bici*": Cycling infrastructure throughout the city".	No	No
Cerasoli, M. et al., 2022 [42]	After	Municipality(ies)	Creation of mobility strategies to favour the use of public transport and environmentally friendly modes of travel	Sustainable Urban Development and Post-COVID Resilience	Adapting Public Space and Prioritising Sustainable Mobility	- Barcelona "*Suppervilles*": Part of Barcelona's master plan adapted to post-pandemic context with a focus on public health. - Milan "*Milano 2020. Strategia di adattamento*": Plans to adapt pavements for social distancing, create "protected" routes, pedestrianise neighbourhoods, reconfigure traffic flows, and reduce commuting. - Bologna: Strategy includes the relaunch of public transport, limitation of peak time journeys, acceleration of active mobility, and valorisation of alternative mobility.	No	No
Delgado-Ruiz, M., 2023 [43]	During/After	Municipality(ies)	COVID-19 emergency that motivated the valorisation of public space	Sustainable Urban Development and Post-COVID Resilience	Adapting Public Space and Prioritising Sustainable Mobility	Tactical urban planning measures were implemented, with small interventions in the city, motivated by the pandemic emergency.	No	No

Author(s)	Intervention Timing	Intervention Drivers	Intervention Purpose	Intervention Domain	Intervention Subdomain	Intervention Description	Contagion as a Variable?	Intervention Outcomes
Evenson, K. R. et al., 2023 [50]	After	Municipality(ies)	Creation of mobility strategies to favour the use of public transport and environmentally friendly modes of travel	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	- Limiting access to infrastructure for pedestrians and cyclists. - Promoting infrastructure for pedestrians and cyclists. - Changes to streets and public spaces. - Automating signals. - Sharing micromobility.	No	No
Firth, C. L. et al., 2021 [51]	During/After	Municipality(ies)	Reducing COVID-19 transmission and promoting time outdoors	Infrastructure and Resource Management	Legal and Administrative Restrictions	Barriers and traffic signs were placed on selected streets to deter car traffic.	No	No
Fischer, J., and Winters, M., 2021 [52]	During/After	Municipality(ies)	Reducing COVID-19 transmission and promoting time outdoors	Dynamisation and Safety in Public Spaces	Adapting public space and urban facilities	Expansion of the pavement: Pavement widened by removing car park. Space enlarged with bollards, posts, paint, and signs. Shared streets: Local streets closed to passing and non-local traffic, open only to local traffic. Barriers, signs, and pavement markings used to indicate the shared street space. Total street closure: Streets closed to all public motor vehicle traffic and reallocated to active transport. Temporary courtyards: Streets closed to create temporary space for sitting and gathering while practising physical distancing.	No	No
Hamman, P. et al., 2023 [46]	During/After	Municipality(ies)	Temporary interventions during lockdown	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	More or less temporary transformations of urban public space in terms of accessibility, with the construction of new cycle paths of various types: bicycle paths, bicycle lanes, "*vélorue*" (bicycle priority), and shared lanes with public transport. Some exclusive pedestrian routes were also expanded and car parks were decommissioned in order to extend open public spaces.	No	No
Harris. M., and McCue, P., 2023 [39]	During/After	Municipality(ies)	Temporary interventions during lockdown	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	Extension of the city's existing network of pop-up cycle lanes.	No	No
Herman, K., and Drozda, Ł., 2021 [31]	After	Municipality(ies)	Temporary interventions during lockdown	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	Extension of cycle paths and pedestrian areas; improvement of the surroundings of cycle paths and pedestrian areas with the introduction of vegetation; new pocket parks; tactical urbanism; redesign of parks; deactivation of car parks for the extension of terrace and leisure areas; "social distancing lawn".	No	No

Author(s)	Intervention Timing	Intervention Drivers	Intervention Purpose	Intervention Domain	Intervention Subdomain	Intervention Description	Contagion as a Variable?	Intervention Outcomes
Kim, J., 2022 [53]	During/After	Municipality(ies)	Understanding the impact of the programmes adopted on public health	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	The "Slow Streets" programme, implemented in several North American cities in 2020, consists of actions by local governments that created temporary public spaces on certain residential streets in these cities, closing off passing traffic with the use of temporary barricades, such as orange barrels, traffic cones, posters, and signs.	No	The "Slow Streets" programme and tactical urbanism were temporarily effective during the pandemic. However, it is challenging to fully evaluate their effectiveness due to the lack of data and literature. Nonetheless, it has been shown that tactical urbanism needs to involve communities of colour more in planning and should be part of a broader, more inclusive strategy, especially for disadvantaged communities.
Kim, J., 2023 [44]	During/After	Municipality(ies)	Temporary interventions during the COVID-19 lockdown	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	"Slow Streets" programme: Adapting/extending existing cycle paths and mixing modes on the same roads. Also includes the banning of car traffic on some structural roads in the cities under study, making them exclusively pedestrianised and/or accessible using soft mobility.	No	No
Krajnović, M. et al., 2023 [38]	After	Municipality(ies)	Adapting open-air schools for today's post-COVID times	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	Connection of the playgrounds of primary schools in 3 Croatian cities with the surrounding public space, removing barriers.	No	No
Kurth, D., 2022 [40]	After	Municipality(ies)	Building a resilient city	Sustainable Urban Development and Post-COVID Resilience	Post-COVID Urban Recovery	Vienna: With the "Smart City Vienna" strategy, actions were implemented such as the "mobility hub", which combined car traffic, public transport, and bicycle traffic to reduce car traffic and car parks in the city centre. Also, the "biotope city" was created, combining a dense urban structure, energy efficiency, green façades, green roofs, and walkable public spaces. Rotterdam: Based on the action plan in place, measures such as floating offices or cyber protection of the harbour were implemented. This strategy stands out in particular for its focus on water management and climate adaptation strategies.	No	No
Moreno, C. et al., 2021 [37]	During/After	Municipality(ies)	Measures to adapt public spaces to the lockdown situation caused by COVID-19	Dynamisation and Safety in Public Spaces	Adapting Public Space and Urban Facilities	Extension/construction of cycle paths/pedestrian areas; maze-like parks; hyperlocal micro-markets; shipping-container hospitals; pop-up stores; outdoor restaurants; small homeless shelters.	No	No

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Nello-Deakin, S., 2022 [61]	During/After	Municipality(ies)	Measures that allowed the population to continue to enjoy public space safely	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	Small interventions were implemented in the city as a way of adapting its use during the pandemic emergency. These measures included the creation of carriageways, bus lanes, bicycle lanes, and tactical urban planning interventions.	No	No
O'connell, E. M. et al., 2022 [32]	During/After	Municipality(ies)	One-off measures that allowed people to continue to enjoy public space safely, even in a confined environment, while maintaining socialisation	Dynamisation and Safety in Public Spaces	Adapting Public Space and Urban Facilities	Extension of the number of terraces and other open spaces for socialising in the vicinity of catering establishments.	No	No
O'Keeffe, P., 2022 [54]	During	Young residents	Overcoming problems of social isolation in times of confinement	Dynamisation and Safety in Public Spaces	Informal Urban Recreation	The construction of "dirty jumps" (small ramps built with earth from the site itself, which are used to practise bicycle sports). This type of construction was initially carried out by young people in Melbourne, and, later, in some specific cases, such as in the municipality of Nillumbbik and the town of Moonee Valley, the municipalities themselves created their own infrastructure for practising BMX and other extreme sports that include the use of dirty jumps.	No	No
Pradifta, F. S. et al., 2021 [58]	During	Municipality(ies)	Documenting all the tactical urbanism interventions applied in cities around the world during COVID-19, intended to be temporary applications to improve urban public space	Sustainable Urban Development and Post-COVID Resilience	Adapting Public Space and Prioritising Sustainable Mobility	- Pop-up cycle path - Salatiga Market and Tugu Traditional Market with physical distancing measures - Safe pilgrimage ritual at the Hajj Pilgrimage Tawaf Strip - Providing food for the homeless and detained migrant workers - Social distancing and physical distancing markings in various public spaces and markets - Creation of pedestrian and cyclist priority zones - Temporary park in the city's Arts Bishop District - Street closures and changes to opening hours of establishments	Yes	No

Author(s)	Intervention Timing	Intervention Drivers	Intervention Purpose	Intervention Domain	Intervention Subdomain	Intervention Description	Contagion as a Variable?	Intervention Outcomes
Ravagnan, C. et al., 2022 [35]	During/After	Municipality(ies)	Presenting a city model for Sapienza in Italy, based on good practices in other European cities, particularly Spain and Italy	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	Milan has focused on reactivating public spaces, promoting outdoor activities, and implementing 30 km/h zones. Barcelona emphasises its dense urban model as effective for urban quality. Turin is promoting sustainable, shared, and electric mobility. Bologna is focused on promoting active mobility and reconfiguring spaces for traffic and car parking.	No	No
Rossitti, M. et al., 2023 [55]	Before/During/ After	Municipality(ies)	To study the economic impact of tactical urbanism interventions, not only after COVID-19 but also before, to understand their influence on the property market in the various Italian cities	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	Piazza del Popol Giost (Reggio Emilia, 2020): Pedestrianisation and street furniture. Piazza Santa Maria del Fonte (Bari, 2020): Pedestrianisation and sustainability. Via Milano (Bologna, 2021): Spatial reconfiguration and pedestrianisation.	No	Piazza del Popol Giost in Reggio Emilia (2020): The intervention resulted in a 15.77 per cent increase in the average value of the residential market in the catchment area between August 2014 and October 2022. Piazza Santa Maria del Fonte in Bari (2020): This intervention led to a 29.71 per cent decrease in the average value of the residential market in the area of influence over the same period. Since January 2017, the decrease has been 14.73% and, since January 2020, there has been a slight decrease of 1.30%. Via Milano in Bologna (2021): The intervention resulted in a 13.09% increase in the average value of the residential market in the catchment area between August 2014 and October 2022. Since January 2017, the increase has been 12.91% and, since January 2020, there has been an increase of 2.03%.

Author(s)	Intervention Timing	Intervention Drivers	Intervention Purpose	Intervention Domain	Intervention Subdomain	Intervention Description	Contagion as a Variable?	Intervention Outcomes
Saravia-Madrigal, M., 2021 [59]	Before/During	Municipality(ies)	Critically evaluate the plan implemented in the city of Valladolid	Sustainable Urban Development and Post-COVID Resilience	Adapting Public Space and Prioritising Sustainable Mobility	In 2012–2020, the General Urban Planning Plan was revised, focusing on urban structure, infrastructures, and citizens' rights. The Eastern Strategy aimed for railway integration, parks, and recreational areas. Plans included creating an Agri-Food and Logistics Park and promoting new housing initiatives. Strategies also aimed to improve neighbourhoods and rehabilitate the urban area by promoting Passivhaus and decarbonising buildings.	No	No
Schwimmer, E., and Schaufler, C., 2023 [45]	During/After	Municipality(ies)	Resolve the issue of sudden changes in the flow of use of urban public space, as happened with the COVID-19 pandemic	Infrastructure and Resource Management	Innovation in Infrastructure and Mobility	"Schanigarten" is a temporary *terrace café* introduced in Munich during the COVID-19 pandemic to help restaurants comply with outdoor distance requirements. A "Connected Campus with emission-free mobility" project is underway, including smart amenities and space for student accommodation. "Pop-up bike lanes" were implemented in Stuttgart to revitalise public spaces, and a "One-minute city" urban model is being tested in Stockholm to focus on residents' street-level concerns. These concepts are flexible for residents' needs.	No	No
Stevens, Q. et al., 2023 [56]	During/After	Municipality(ies)	Testing new possibilities for post-COVID governance, incorporating adaptability into the design of parklets, and serving as a platform for new modes of social and spatial play.	Sustainable Urban Development and Post-COVID Resilience	Adapting Public Space and Prioritising Sustainable Mobility	Playful parklets: A parklet is a small, relocatable public space installed in car parking spaces next to the pavement. In 4 parklets located in the city of Melbourne, activities were organised to activate the "playful" aspect of these infrastructures. Activities included music, floor painting, sensory activities with plants, workshops, dancing, reading, games, etc.	No	No
Verhulst, L. et al., 2023 [57]	During/After	Municipality(ies)	Documenting examples and solutions for remodelling accessibility and public space, also raising questions about social justice in these interventions	Dynamisation and Safety in Public Spaces	Adapting Public Space and Urban Facilities	"Meeting circles" in squares; Safer Busy Streets programme; Calle Reloncaví; shared streets initiative; street turned into a park; holiday streets/playground streets; organising indoor activities in outdoor spaces by clearly demarcating activities; installing flower beds to separate street furniture; organising normally indoor events outside; redistributing street space: moving pedestrians onto cycle paths and cyclists onto carriageways; providing (workshops on) sustainable and active modes of mobility; installing temporary shared mobility centres.	No	No

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