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Changes in Urban Planning in Response to Pandemics: A Comparative Review from H1N1 to COVID-19 (2009–2022)

Kangwei Tu [1,2] and Andras Reith [3,4,*]

[1] Marcel Breuer Doctoral School, Faculty of Engineering and Information Technology, University of Pécs, Boszorkány u. 2, 7624 Pécs, Hungary
[2] Department of Architecture and Urban Planing, School of Civil Engineering, Architecture and Environment, Hubei University of Technology, Wuhan 430068, China
[3] Advanced Building and Urban Design, Orlay Street 2/b, 1114 Budapest, Hungary
[4] BIM Skills Lab Research Group, Department of Engineering Studies, Faculty of Engineering and Information Technology, University of Pécs, Boszorkány u. 2, 7624 Pécs, Hungary
* Correspondence: reith.andras@abud.hu

Abstract: The COVID-19 pandemic has brought enormous casualties and huge losses to cities around the world, causing urban planning to reflect on its serious inadequacy in public health crisis management. Looking back at the pandemics of modern history, urban planning has been dedicated to enhancing disease prevention capacity as well as improving the wellness of human beings. By systematically comparing the urban planning response between COVID-19 (2019) and its predecessor H1N1 (2009) in the literature, this paper seeks to explore how urban planning theories evolved through the pandemics and whether COVID-19 has led to possible new implications and directions for urban planning in the future. A total of 3129 related results with overlapping themes of "city", "pandemic", and "planning" in the database were narrowed down to 30 articles published between 2009 and 2019 on the topic of H1N1 and 99 articles published between 2020 and 2022 on the topic of COVID-19 after careful extraction and integration. Through bibliographic and detailed analysis, twelve urban theories used to fight against pandemics were identified. In addition, three main changes between urban planning responses to the H1N1 and COVID-19 pandemics were summarized: from focusing on stages of "in-pandemic" and "pre-pandemic" to focusing on stages of "post-pandemic", from global and national to local, and from the absence of an urban-built environment to a return to 'healthiness' in urban planning and design. Such comparisons are useful for examining the current situation and providing suggestions for a possible upcoming outbreak.

Keywords: cities; pandemics; urban planning; public health; urban theories

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1. Introduction

On 5 May 2023, the World Health Organization (WHO) declared that COVID-19 no longer constituted a "public health emergency of international concern (PHEIC)", bringing to an end a worldwide pandemic that had lasted more than three years [1]. During this period, the cities at the epicenter were exposed to a variety of problems: shortages of medical resources, disruptions in transport and logistics, poor risk communication, and uneven spatial distribution of infrastructure [2–4], all of which demonstrated that urban planning was still inadequate in responding to public health emergencies and posed new demands on urban planning in the future.

However, pandemics have not affected cities for the first time in human history. Looking back at just two short decades since the turn of the century, outbreaks of emerging infectious diseases have been continuously identified, such as severe acute respiratory syndrome (SARS) in 2003, influenza H1N1 in 2009, Middle East Respiratory Syndrome (MERS) in 2014, Ebola in 2014 and 2018, and Zika in 2016. Frequent crises have deepened the understanding of urban planning in responding to infectious diseases. History proves

that urban planning does not evolve abruptly but gradually, building on past experience [5]. Just as the healthy environment of modern cities (e.g., clean water, waste disposal, good light, ventilation, etc.) has developed progressively in the wake of major public health crises such as cholera and plague since the 19th century [6,7]. At present, however, most studies have focused on the single outbreak of COVID-19, and there are fewer historical retrospective studies, which can be divided into two categories. One category compares COVID-19 with the 1918 flu, showing that both have a catastrophic impact on the globe and analyzing the similarities in urban responses [8,9]. The other category summarizes a large span of events from the 1918 flu to COVID-19, illustrating how urban planning intersects with a public health response through thematic studies [10,11]. For the first type, the 1918 flu is fundamentally different from COVID-19, considering that the processes of globalization, along with the advances in medicine, epidemiology, and information technology, have altered the way that pandemics are experienced, understood, and controlled [12]. Likewise, for the second type, given the gap between "endemic", "epidemic", "PHEIC", and "pandemic", the severity and scope of their attacks on cities vary considerably, and cities respond in disparate ways. For example, SARS, with only 8000 cases detected worldwide [13], and MERS, which was concentrated especially in Saudi Arabia [14], were also caused by coronaviruses, but they did not meet the criteria to constitute a pandemic. Therefore, in general, there is a lack of research into the latest developments in urban planning responses to pandemics.

Reviewing the major global public health crises of this century, there have been two pandemics as defined by the WHO: the COVID-19 pandemic and the 2009 H1N1 pandemic. The H1N1 pandemic, which circulated from early 2009 to late 2010, spread in 198 countries and regions around the world and caused at least 575,000 deaths, causing serious damage to the global socioeconomic environment [15]. Although the 2009 pandemic was relatively mild [16], it shared a similar policy and technical background to COVID-19. On the one hand, it was the first real-world campaign since the entry into force of the revised International Health Regulation (2005), which provided a legal framework and a specialized mechanism for collective global action [17]. On the other hand, it was the first time that large-scale surveillance and computer modeling were applied to provide assessments of the impact level [18] and effectiveness of possible control measures [19] in the outbreak. The 2009 pandemic was derived from influenza viruses rather than coronaviruses, but as respiratory infections, there are many similarities in prevention practices between them, particularly social policy initiatives such as social distancing, travel restrictions, avoiding public gatherings, and school closures [20]. Therefore, H1N1 and COVID-19 provide excellent material for understanding the recent developments in urban planning in response to pandemics. Despite this, no such comparative review still exists.

To fill the gap, by systematically reviewing the historical literature on the pandemics of H1N1 and COVID-19 and their documented connections to urban planning, this study seeks to explore which urban planning theories or models were used in response to the two pandemics and how they evolved through the past decade. Meanwhile, the main changes in urban planning in coping with the COVID-19 pandemic and its predecessor are highlighted, identifying whether COVID-19 has upgraded capacities/theories/techniques, which presents future trends. Through analysis of the developing situation, it will suggest priorities for urban planners and policymakers and help cities better prepare for the next outbreak.

2. Methods

The research developed a systemic literature review protocol supported by Petersen et al., (2015) [21]. This part illustrates the methodology in the following three steps: (1) paper searching, screening, and selection; (2) bibliometric analysis, which includes general statistics analysis and network analysis; and (3) detailed analysis.

The following diagram (see Figure 1) further illustrates the connections between the above methods and research objectives.

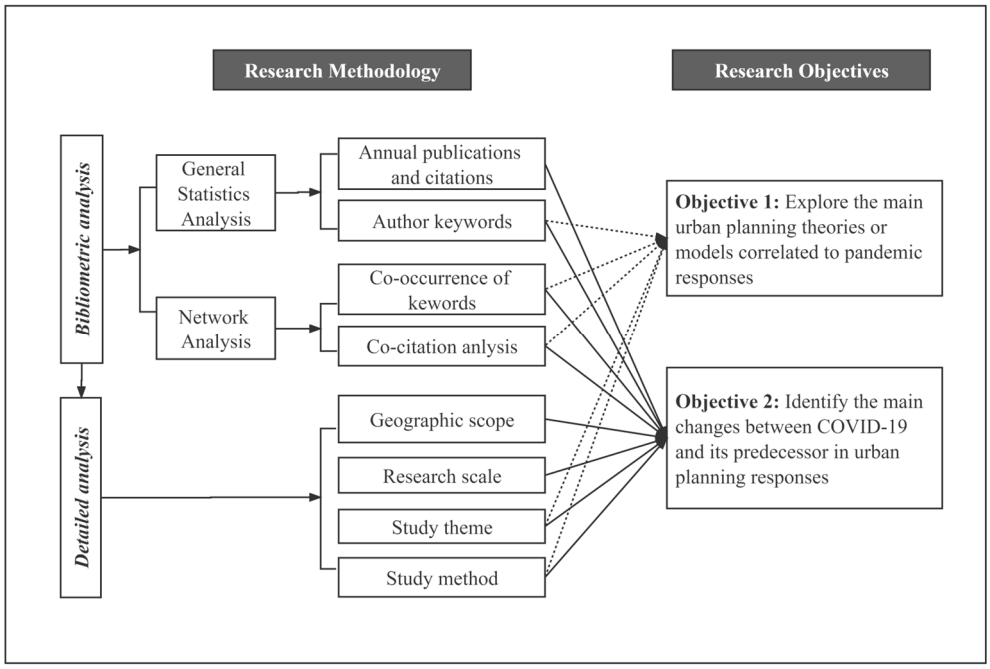

Figure 1. Schematic diagram of this comparative review.

2.1. Paper Searching, Screening, and Selection

2.1.1. Data Collection and Identification

The objects of this study are relevant papers indexed in the Web of Science (WOS), a commonly used database for scientific articles. The search field was limited to peer-reviewed articles from well-known academic publishers.

Corresponding to the second research question, which sought to determine if there were any changes in the theoretical application and practical tools of the COVID-19 response from the previous one, the search was carried out in two individual lines. To better compare the COVID-19 and H1N1 responses, the search formula was exactly the same as keywords comprised one term from "pandemic" or specific virus names such as "h1n1", "swine flu", "COVID", "coronavirus" and one term from "city" feature words such as "cities" or "urban", and one term from "planning" or "design". According to the time periods of the two pandemic outbreaks, they were searched, respectively.

For h1n1: TITLE-ABS-KEY ("pandemic" OR "h1n1" OR "swine flu") AND ("urban" OR "city" OR "cities") AND ("planning" OR "design") between the publication years from 2009 to 2019.

For COVID: TITLE-ABS-KEY ("pandemic" OR "COVID" OR "coronavirus") AND ("urban" OR "city" OR "cities") AND ("planning" OR "design") between the publication years from 2020 to 2022.

In addition, there was no direct input of urban theory keywords in the whole searching process, unlike previous studies [10], as forecasts in advance about which theories were relevant to pandemic response may greatly disturb objective facts. This research hoped to deduce the correlation between urban theories from the results.

2.1.2. Screening and Eligibility

Through an iterative searching cycle from September 2021 to May 2023, there were a total of 3123 articles on both COVID-19 and H1N1 topics. A brief screening revealed that many articles include the above keywords in the title or abstract where efforts relate to other disciplines such as medicine, pharmacy, or nursing. Therefore, the filtering function of the Web of Science was used, and 496 articles stayed after selecting only the category of "urban studies". Additionally, material identified as book chapters, book reviews, letters, editorials, and notes were excluded as most of them lack keywords to conduct network analysis. By

checking the abstracts of the rest, articles that only referred to the terms "COVID" or "h1n1" in the abstract rather than putting them as the main focus were excluded. At the end of this stage, 334 articles remained in the database.

After reviewing the full text of these articles to ensure their relevance, 228 more articles that failed to meet all six criteria below were removed. The inclusion criteria were: (1) it proposed a response or solution to the pandemic from a theoretical perspective, not just an operational one; (2) it was urban planning-related rather than discussing certain aspects alone such as water/food/finance, etc.; (3) the city (or even larger geographic areas) was studied rather than focusing on public space or architecture scale; (4) it focused on H1N1 or COVID-19 only; (5) it focused on urban areas, not rural areas; and (6) it was written in English.

In addition, 15 papers were added to the database through the scrutiny of reference lists. In the end, 129 studies were included, of which 30 came from H1N1 and 99 from COVID-19 (Figure 2).

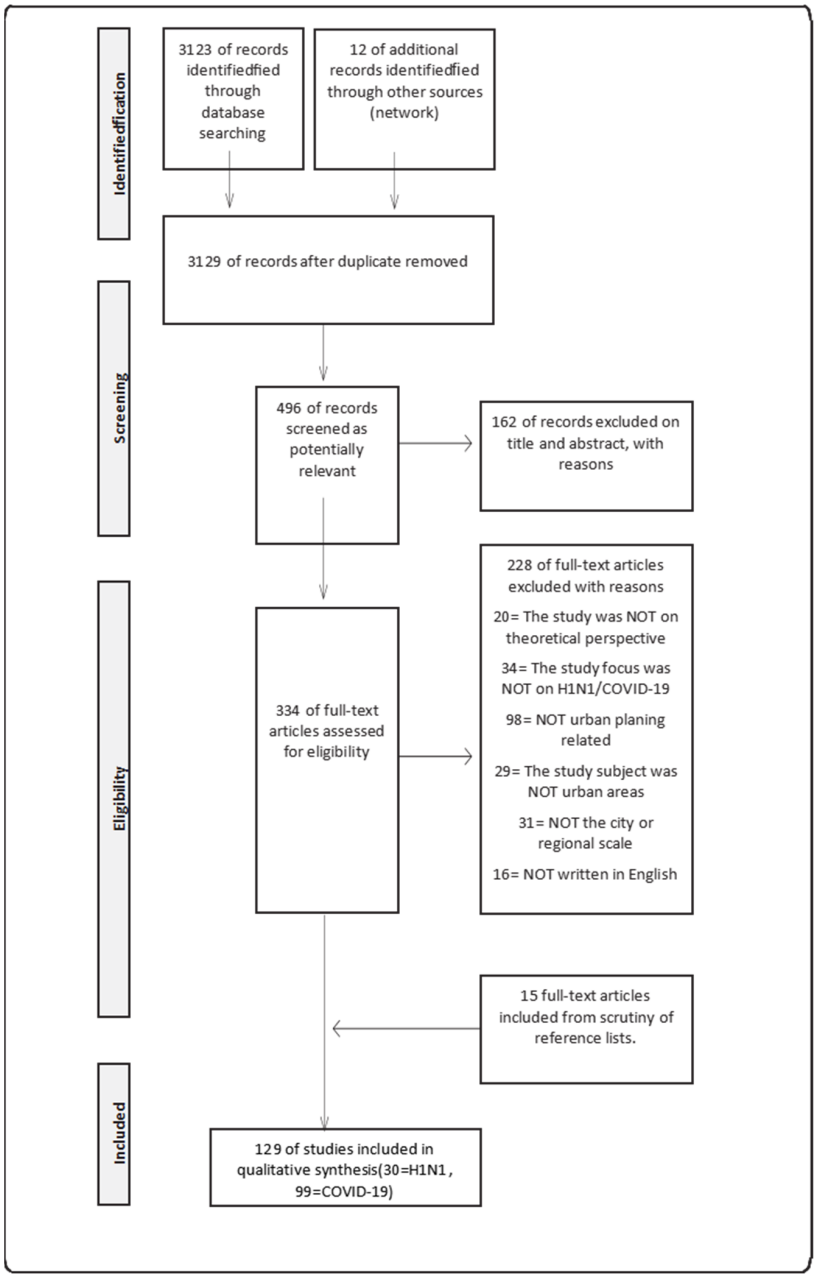

Figure 2. Flow diagram summarizing the literature search process.

2.2. Bibliometric Analysis

Two information extraction sheets were developed in Microsoft Excel 16.74 to collect evidence on different items in the included papers on H1N1 and COVID-19 topics, respectively. First of all, data including title, authors, publication year, author keywords, and total and per-year citations were obtained from the Web of Science. The author's keywords may imply applications of certain urban concepts or theories that need to be specifically highlighted.

Network analysis mainly includes co-occurrence keyword analysis and co-citation analysis. As the keywords served as the very essence of research concepts, methodologies, and themes, using co-occurrence keyword analysis could indicate the patterns and trends of various pandemic-response domains [22]. While co-citation analysis can easily help find the most popular publications and, in particular, verify whether there is a co-reference to the same urban theories or concepts between H1N1 and COVID-19 responses. Both of them, based on network theories, have been confirmed to be very useful in identifying concepts with integrative characteristics. Therefore, they were used in this paper to quickly figure out the possible theoretical system for urban planning responses to the two pandemics.

With the aid of the software VOSviewer 1.6.18 [23], the results of network analysis can be better presented. A minimum of two variables, either co-occurrence or co-citation, can be set as the threshold for interactions. The total strength of the bibliographic coupling linkages with other items was calculated [24]. The size of the node implies the frequency of keyword occurrence or citation, while the distance between them indicates their relative co-occurrence or co-citation. The analytic method of the "LinLog method and modularity clustering technique" was used to display the network map with same-colored keywords grouped into one cluster, which can help identify rapidly expanding subjects and regions of collaboration in urban planning responses to pandemics [25]. Special attention was also given to studying the growth of scientific concepts and propositions through their evolution process. "Overlay visualization technique" was selected to show the focus change from H1N1 to COVID-19 with a timeline according to the average year of keywords in the co-occurrence network.

2.3. Detailed Analysis

The detailed analysis aimed to further explore the new research areas, principles, methods, and tools that emerged in urban planning during the COVID-19 period. The preceding bibliometric analysis can provide a broad distinction between the two periods regarding the number of studies and research hotspots, but it was not sufficient to dig deeper into the developmental changes within urban planning in response to pandemics. Therefore, a detailed review was necessary. By using an inductive content-analysis method [26], which derived comprehensive cognition from fragmented information, all included papers were categorized in terms of geographic scope, research scale, study method, and specific theme and filled back in the table mentioned in Section 2.2. To ensure a controlled and consistent data analysis of the target literature, two authors held several meetings during the data collection phase and initially developed a standardized data extraction form (Excel). A pre-review was then performed by two authors who separately extracted information from the same part of publications in the target literature, and the results showed an agreement rate of more than 90%. After reexamining the contents for reasonableness, partial changes were made to the data extraction sheet. After this step, both authors reviewed all publications and completed the final information extraction. By comparing the similarities and differences between H1N1 and COVID-19 studies from the sheet, it helped to better understand the trends in the development of urban planning in response to pandemics.

3. Results

Corresponding to the two main research methods, the results section first presents a statistical comparison of the two parts of the literature on the topic of H1N1 and COVID-19, followed by a detailed description of the results of thematic analysis for both.

3.1. General Statistics of Publications

3.1.1. Annual Publications and Citations

The number of publications in the literature about H1N1 and COVID-19 differed significantly, which was evident in the result of the searching process. Figure 3 confirmed it with a detailed list of annual publications and citations. In the two years between the onset of swine flu in early 2009 and WHO declaring its end in late 2010, there were only five articles included as target articles. Till the end of 2019, review articles related to H1N1 were updated at an extremely slow annual rate. In 2020, urban studies responded to the global outbreak of the COVID-19 pandemic in the first instance with 20 publications, which surged to 60 in 2021. Similarly, a doubling increase in citations could also be seen, indicating a fast-growing interest in this field. The number of studies started to decrease sharply in 2022, but the number of citations was still significant.

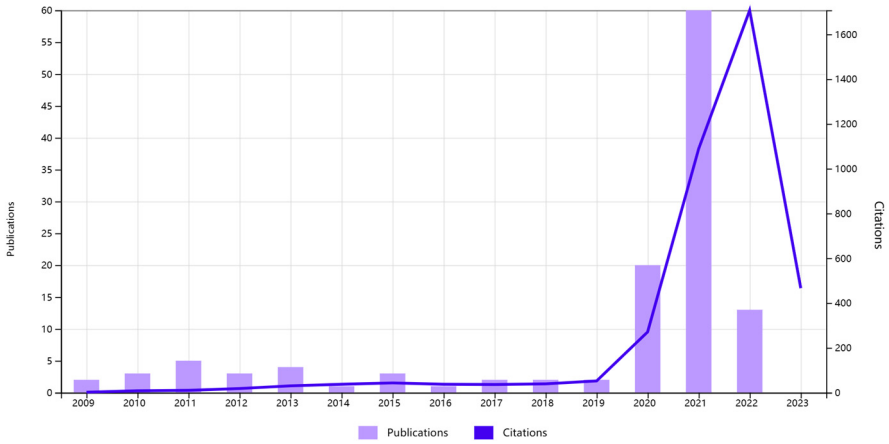

Figure 3. The number of included articles by year (2009–2022).

3.1.2. Author Keywords

Through the keyword count, a total of 12 keywords related to urban theory were identified. The most frequently studied urban theory was 'resilience', followed by 'smart cities' and 'sustainability'. The rest of the urban theories were 'vulnerability', 'healthy city', '15-min city', 'compact city', 'tactical urbanism', 'temporal urbanism', 'informal urbanism', 'livable city', and 'Weberian city'. The association of H1N1-related research with urban theories was rare, with the author keywords 'vulnerability' and 'Weberian city' appearing only once each. In contrast, complex and diverse urban theories emerged from COVID-19-related urban planning studies.

Another noteworthy point is the association between urban theories. In the selected target articles, it is not uncommon for multiple urban theories to appear together in the authors' keywords, in which the terms "resilience" and "smart cities" and "resilience" and "sustainability" appear most frequently together. Additionally, "resilience" and "vulnerability", 'smart cities' and 'tactical urbanism', and 'sustainability' and 'livable city' suggest that these theories have overlaps in providing effective prevention and control pathways for pandemics.

3.2. Network Analysis of Publications

3.2.1. Keywords Co-Occurrence Analysis

After keywords were combined with synonyms and low-frequency words were removed, the cluster of keywords and co-occurrence network were generated. There were 139 of the 647 keywords (including author keywords and keywords plus) that met the threshold requirement of three occurrences.

As shown in Figure 4, it was obvious that COVID played a far more important role compared with H1N1 in pandemic-response urban studies. In addition to this, pandemic

presented strong relations with the terms "resilience" (15 occurrences, 44 links, and 76 total link strength), "smart cities" (12 occurrences, 39 links, and 63 total link strength), and "sustainability" (9 occurrences, 34 links, and 47 total link strength), followed by "vulnerability" (5 occurrences, 21 links, and 29 total link strength), which were the main four urban theories. Although 12 theoretically relevant key words were collected in Section 3.1.2, it was now judged through analysis that the other words did not occur with sufficient frequency to be included in the main theories responding to pandemics.

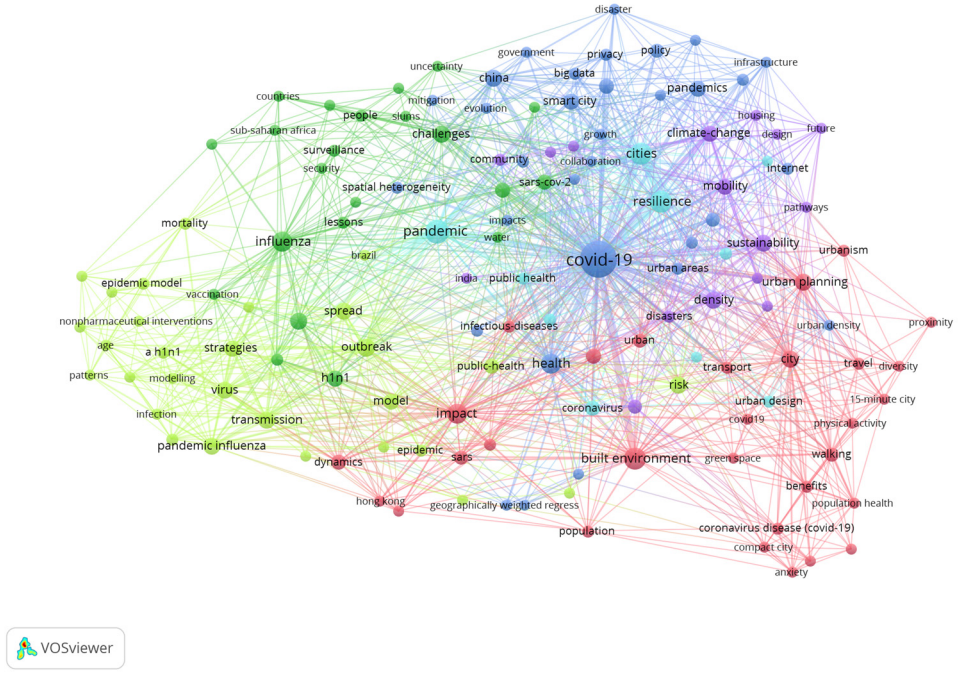

Figure 4. Keywords co-occurrence analysis of H1N1 and COVID-19 responses in urban planning.

There were in total six clusters, and each cluster accounted for about 21% (yellow-green, 16%(green), 7% (light blue), 23% (dark blue), 11% (purple), and 22% (red) of all keywords, respectively. Keywords in the same color indicated their close association and more established research ties. In this context, "vulnerability" was strongly related to the "preparedness" phase, especially in relation to populations, slums, uncertainty, etc. The scope of "smart cities" was more focused on the "urban governance" dimension, working closely with big data, infrastructure, and urban policies. In contrast, the keywords closely associated with "sustainability" and "resilience" did not focus on a specific area. For example, there were both "climate-change" and "mobility", "density", and "housing" in the same group as "sustainability", while "urban form", "public health", and "pandemic planning" were in the same group as "resilience".

The changes in domain from 2009 until now could be clearly observed from the outputs of keyword co-occurrence analysis with the aid of "Overlay Visualization" in Figure 5. Among the 139 keywords, 45 were related to H1N1, while the other 94 were related to COVID-19, which showed the color transition from cold to warm (representing the time transition from the year 2010 to 2020). There are three main time periods:

- 2009–2015 (in color blue to grey)

The high-frequency keywords at that time were: "virus", "pattern", "modeling", "transmission", "strategies", "school closure", "vaccination", and "NPIs" (non-pharmaceutical interventions).

- 2016–2019 (in color flesh to salmon pink)

The high-frequency keywords at that time were: "impact", "preparedness", "public-health", "people", "slum", "lessons", and "pandemic planning".

- 2020–2022 (in color red)

The high-frequency keywords at that time were: "resilience", "sustainability", "smart cities", "vulnerability", "built environment", "density", and "mobility".

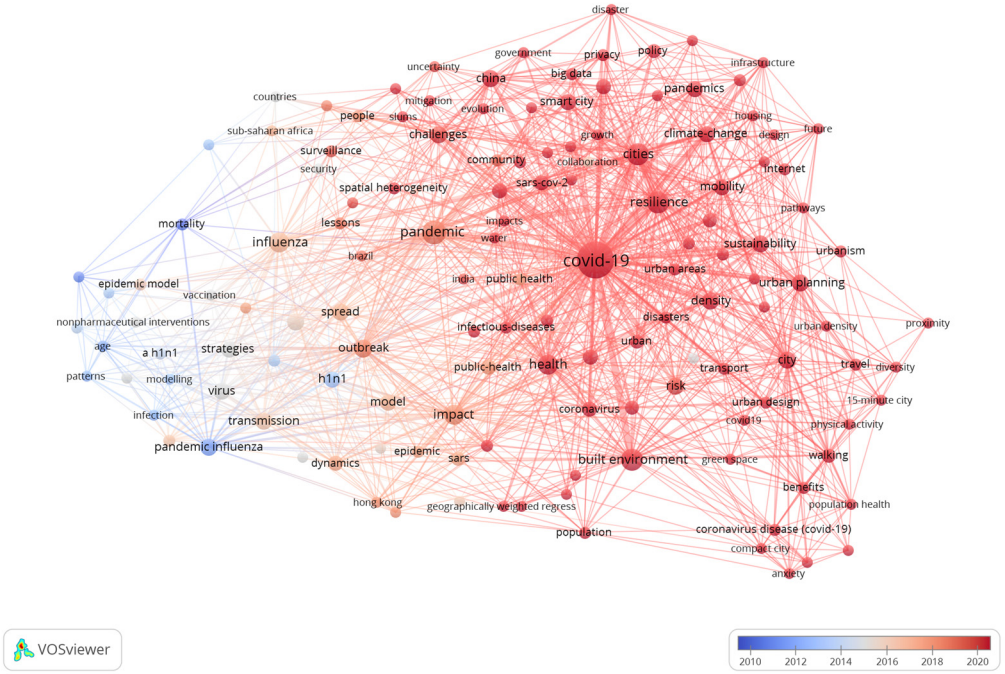

Figure 5. Keyword co-occurrence analysis of H1N1 and COVID-19 responses in urban planning overlaid with time (2009–2022).

It is notable that the keywords related to H1N1 before 2020 basically overlapped with the yellow-green and green clusters from the network map, which implied that studies related to H1N1 focused more on protocol phases such as virus "transmission", "intervention" methods, and "preparedness" for pandemic planning. The application phase of the H1N1 study stayed in the 'mid-pandemic' and 'pre-pandemic' tenses, while COVID-19, on the other hand, focused more on the 'post-pandemic' outcome, exploring how to build more desirable cities (especially in terms of management and environment) through a number of studies linking pandemic to urban theories, which echoed with blue, light blue, purple, and red clusters.

3.2.2. Co-Citation Analysis

There were 6757 references in all included papers, of which 31 reached the threshold, with six as the minimum number of citations for a cited reference (Figure 6). Notably, the highest co-cited references were concentrated after the year 2020, implying no strong research succession between COVID-19 and H1N1, and equally implying that a new framework for responding to the outbreak was formed during the COVID-19 period. The pre-2020 literature with the highest number of co-citations was mainly clustered in the three articles from 1991 to 2009 [18,27]. The same color showed a high degree of association between them, all with a bias towards strategies for mitigating pandemics. In Table 1, the top four papers with the highest co-citation frequency (all published in 2020) were summarized, including their titles, sources, and ideas, providing important clues to understand the mechanism of pandemic responses and insights into domains of knowledge.

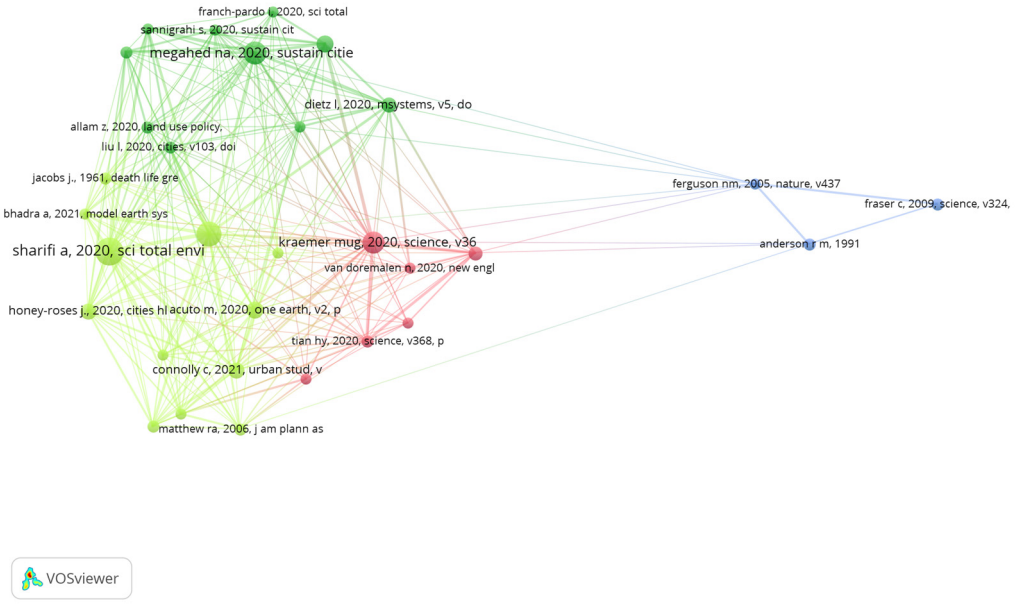

Figure 6. Co-citation analysis of H1N1 and COVID-19 responses in urban planning with 31 top-cited papers between 2009 and 2022.

Table 1. Top four papers with the highest co-citation frequency.

Rank	Title	Co-Citations	Ideas
1	The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management [28]	22	COVID-19 offers great opportunities for planners and policy makers to make transformative actions
2	Does Density Aggravate the COVID-19 Pandemic? Early Findings and Lessons for Planners [29]	20	Planners should continue to promote dense development
3	Antivirus-built environment: Lessons learned from COVID-19 pandemic [30]	17	An antivirus-built environment paradigm is needed
4	The effect of human mobility and control measures on the COVID-19 epidemic in China [31]	15	Shows how control measures implemented in China mitigated the spread of COVID-19

By examination of the objectives and themes of the four highest co-cited papers, it further revealed that the topics were shifted into different directions compared to the pre-2020 period, mainly as follows: (1) public emergency response; (2) health geography basis for decision making; and (3) rethinking urban structure and form. The post-2020 study of public emergency response carried forward, in part, the previous findings that public intervention at the national level can slow the spread of the virus. However, the importance of travel restriction [31–33] was highly discussed in the COVID-19 period compared to the previous household-based prophylaxis coupled with reactive school closure [34]. In addition, a considerable number of studies used GIS (geographic information system) as a basic tool for spatial-temporal analysis and disease mapping to tap into a large number of urban socioeconomic variables, providing a solid basis for the development of pandemic policies [35]. These insights from geography increased the attention and understanding of informal settlements and their inhabitants and reduced the sacrifice or lack of protection for marginalized populations [36]. The last prominent direction was an unprecedented opportunity for positive urban transformation [28,30], given that pandemics have dramatically changed the structure of cities and the lifestyles of their inhabitants. Urban planning

studies during the COVID-19 period, formed in the three main directions above, showed a more comprehensive and interdisciplinary look than those during the H1N1 period.

3.3. Detailed Analysis of Publications

3.3.1. Geographic Scope and Research Scale

The results of the studies on geographical scope showed that urban planning responses in the context of H1N1 were mainly focused on countries in the Americas, Oceania, Europe, and Asia, such as the US, Mexico, Chile, New Zealand, Australia, England, Italy, Hungary, China, and India. In contrast, the geographic scope of studies during the COVID-19 period was much larger, with the addition of Africa and MECA countries. In addition to this, the H1N1 period was mostly studied on a regional or even national basis, with less than 1/3 of the studies on an urban scale. The COVID-19 period, on the other hand, saw a large number of city-based, local responses, accounting for 79% of the total number of targeted articles. There were many city-based case studies, including New York, London, Chicago, Madrid, Bogota, Hong Kong, Wuhan, Tehran, etc.

3.3.2. Study Methods

The study methods of the included papers were divided into four categories: review, conceptual, empirical, and modeling [37]. It was found that review was the most common method in H1N1 studies (63%), while the proportion was reduced to 26% in COVID-19 by the addition of the conceptual approach (14%) and the expansion of the integration of empirical and modeling (27%). Likewise, the method of combining review and conceptual arose (10%) after 2019 (see Figure 7). Conceptual and conceptual, with review articles committed to exploring how pandemics might influence cities, highlighting the opportunities and challenges, and searching for effective strategies, 75% of urban theory keywords are found in this category. A mixture of empirical and modeling approaches was popular in both the H1N1 and COVID-19 literature. This type of approach was mainly based on case studies, examining the relationship between urban factors and pandemic outcomes through surveys, questionnaires, interviews, computer modeling, etc., with modeling approaches being the most frequently used, where the connection with urban theories was weaker.

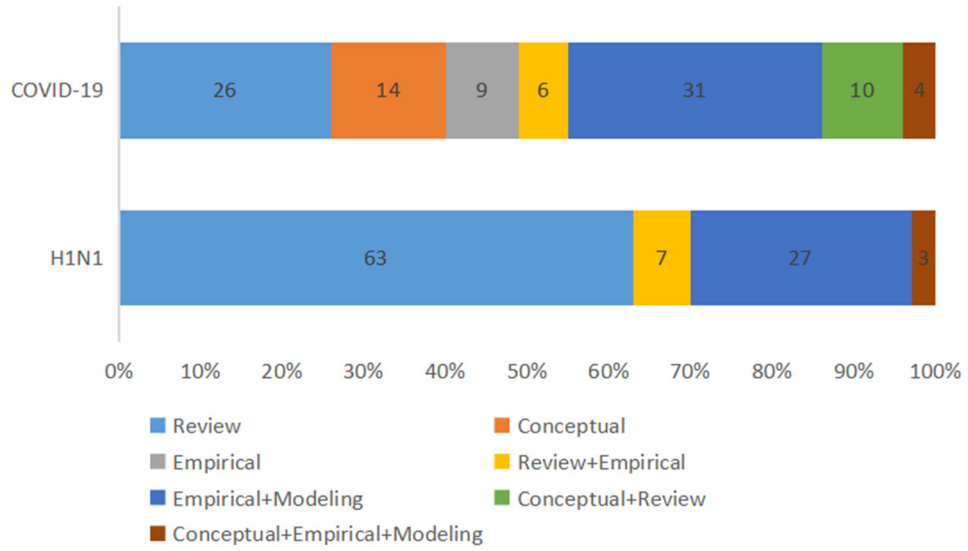

Figure 7. Comparison of study method with percentage.

3.3.3. Study Theme

As one of the results of the information synthesis mentioned in Section 2.2, the total of 129 articles was classified according to five specific themes: (1) governance and policy; (2) built environment; (3) modeling; (4) socioeconomic factors; and (5) post-COVID planning. Table 2 below shows the distribution of H1N1 publications and COVID-19 publica-

tions in the above study themes. On the other hand, urban theory-related author keywords that have been marked in the information extraction sheets found their place under each domain to gain a clearer understanding of the background of the theory's application.

Table 2. Percentage and keywords of articles per study theme of the included papers.

			Occurrence of Urban Theory Keywords											
Study Theme	**Group**	**Percentage (%)**	**Resilience**	**Smart Cities/City**	**Sustainability**	**Vulnerability**	**Healthy City**	**15-min City**	**Compact city**	**Temporary Urbanism**	**Informal Urbanism**	**Tactical Urbanism**	**Livable City**	**Weberian City**
Governance policy	H1N1	57				1								1
	COVID	13	3	6	1									
Built environment	H1N1	0												
	COVID	10	2		1									
Modeling	H1N1	33												
	COVID	10	1		1		1							
Socioeconomic factors	H1N1	10												
	COVID	32	5	1	1	4			1					
Post COVID planning	H1N1	0												
	COVID	35	9	5	5	1	2	3	1	1	1	1	1	
Total	H1N1					1								1
	COVID		20	12	9	5	3	3	2	1	1	1	1	

The target articles on H1N1 topics were distributed in concentrated areas, with 57% on 'governance and policy' and 33% on 'modeling'. However, the proportion of articles in both of these two areas declined rapidly in COVID-19-related research, falling to 13% and 10%, respectively. Instead, studies on future-oriented urban planning rose sharply, accounting for 35% of the overall included articles, while no relevant records existed in the H1N1 era. A comparable situation occurred in the built environment area, where the target article contribution rate reached 10%, achieving another zero breakthrough. Research on 'socioeconomic factors', which held a place in the H1N1 period, also increased significantly during the COVID-19 outbreak, jumping from 10% to 32%. The association of H1N1-related research with urban theories was rare, with the author keywords 'vulnerability' and 'Weberian city' appearing once each in the theme of governance and policy. On the contrary, complex and diverse urban theories emerged from COVID-19-related urban planning studies. It was most widely distributed in the area of post-COVID planning, covering all urban theories except the 'Weberian city'. In addition, 'resilience' and 'sustainability' were the most comprehensive urban theories applied, covering all five themes of studies, which was consistent with the results of the previous analysis in Section 3.2.1.

In terms of theme 1, most urban planning studies during the H1N1 period were based on pandemic preparedness plans at the national and regional levels [38], with a security framework to strengthen urban monitoring and risk assessment during the various phases of the pandemic [39]. The outstanding problems were the conflicting management at national, regional, and local levels [40] and the lack of reliable criteria to judge the phase of the pandemic [39]. By the COVID-19 period, most studies concluded that the focus at the management level remained on monitoring and risk assessment of cities [40,41]. Many articles focused on reviewing the change from human-driven to techno-driven urban management [42], especially the prominent contribution of smart cities to urban governance [43]. The results showed in this period that different techno-

driven policies and actions made crisis management possible [44], enhanced community well-being, maintained urban functionality, and increased city resilience [43].

As for theme 2, the relevant research components of H1N1 and COVID-19 were similar. One was to track the spread of the virus by mathematical modeling and predict the time course of a pandemic; the second was to characterize the link between cities and pandemics through mathematical models; and the third was an assessment of the effectiveness of environmental or social measures to contain an outbreak. Both periods focused specifically on the effectiveness of NPIs, but the COVID-19 period focused on the impact of lockdowns on cities [45] in addition to the traffic control mentioned above, and new technologies such as artificial intelligence [46,47] and digital twin [48] were applied.

In total, two of the three H1N1-period articles on socioeconomic factors focused on the impact of road traffic on the spread of the pandemic [49], in addition to higher population density, higher per capita income, more hospitals and college students, and lower GDP per capita, which were also shown to be associated with higher cumulative incidence [50]. The COVID-19 period included a large number of analyses of built environment factors, including building density, urban form, city connectivity, etc. However, there were also a number of studies recentering the demographic drivers, informal labor [51], low educational attainment [52], the elderly [53], and ethnic minorities [54], arguing that social vulnerability played an important role in the COVID-19 pandemic and highlighting the need to address socioeconomic barriers to pandemic recovery and future pandemic response.

The two remaining themes not covered by H1N1-era studies were the built environment and post-COVID planning. The built environment was identified in the COVID-19 era as having an important role to play in supporting public health measures and reducing the risk of infections. Afterwards, by analyzing data from a large sample of the built environment, land use, commercial facilities, and transportation infrastructure were all considered to be highly statistically related to the number of confirmed cases [55]. On the other hand, there were studies that believed that COVID-19 had or was about to change the built environment [30], and major shifts might be possible in architecture practices, civil engineering practices, project management, and urbanism [56]. There were four main directions in the research on post-COVID planning. One viewed the city as a systemic whole and considered that a comprehensive and integrated prevention system for multi-urban disasters must be developed in future urban management [57]. The second focused on the transformation of urban space, from home, neighborhood, workplace, public green space, streetscape, transportation, and even urban morphology, in a new paradigm [58–60]. While the third one advocated a green urban recovery path through the transition of urban mobility, energy, food, housing, and health systems [61,62]. Moreover, the last one emphasized the significance of smart solutions, encouraging a more inclusive tech-led development to enhance fair, resilient, and sustainable cities [63]. These aspects were not completely independent but intersected with each other, so some studies actually explored more than one of these aspects [64].

4. Discussion

4.1. Study Themes and Identified Theories

Judging from the results in Section 3.3.3, the application of urban theory in the period of H1N1 and COVID-19 can reflect the trend from single to multiple. Even if the "smart city" (2010) was later than the outbreak of H1N1 (2009). However, urban theories such as healthy cities (1986) and sustainability (1987), which were mature before H1N1, did not appear in the H1N1-related studies, showing the great expansion of the theoretical boundaries of urban planning in the COVID-19 period. On the other hand, no new theories have been observed in the current research on the COVID-19 pandemic, but rather an evolutionary synthesis based on multiple existing ones. In terms of the breadth of the research field, the urban theories of "resilience", "sustainability", "smart cities", and "vulnerability" are more comprehensive in their coverage, and they have proposed solutions in aspects of environment, society, and economy in the context of the complexities of COVID-19. The application

of "smart cities" in urban governance is particularly prominent [43], while "vulnerability" plays a greater role in the field of socioeconomic factors [65]. While "sustainability" and "resilience" are covered under all themes, they contribute most prominently to the theme of "post-COVID planning", showing theoretical leadership for urban planning in response to future pandemics. Other urban theories have been studied less in pandemic response and are limited to a single field. For example, "15-min city" focuses only on the physical form of the city, in particular on reducing the health burden of cities in terms of transport through more compact land use patterns and proximity to service [66].

Although each urban theory has its own priorities under the study theme, the results of the analysis in Section 3.1.2 show many overlaps in the application of urban theories, suggesting a trend toward convergence of theoretical systems for urban planning responses to pandemics. The ICT-based "smart city" theory can assess the severity and scale of infection in the early stages of pandemics, which can help identify areas with high "vulnerability". A circular bio-economy model based on the goal of "sustainability" would greatly ease the strain on critical supply chains (e.g., food, personal protective equipment), in line with the "resilience" theory that emphasizes the redundant characteristics of cities. Likewise, a "smart city" utilizes key information technology in connection with urban facilities and services to reduce the negative impact on quality of life, thereby helping to achieve the goal of a "livable city". "Tactical urbanism", "informal urbanism" and "temporary urbanism" provide concrete strategies for the implementation of local-based adaptive governance in "resilience". Furthermore, the application of "sustainability" and "resilience" also contributes positively to a "healthy city", especially in terms of climate and environmental restoration measures that also contribute to the restoration of people's mental health.

The crisis caused by coronavirus disease provides a new opportunity for disciplinary integration, with a wide range of research perspectives and scope for development. At present, it is difficult to quantify the role of each urban theory in coping with pandemics, but it is certain that the intersection of multiple theories will become more common in the future. Likewise, by clarifying the interrelationship among different urban theories, it is expected to combine and establish a more complete and systematic response framework.

4.2. Comparisons of H1N1 and COVID-19 Responses

4.2.1. Change-1: From Stages of "In-Pandemic" and "Pre-Pandemic" to the Stage of "Post-Pandemic"

Keyword co-occurrence analysis from Section 3.2.1 shows that the urban planning studies related to H1N1 were mostly concentrated in the stages of "pre-pandemic" and "mid-pandemic", while those related to COVID-19 were mostly concentrated in the stage of "post-pandemic". The early studies of H1N1 (2009–2015) were linked to the pandemic from its outbreak to its cooling-off. As visibility and transmissibility were identified as the key drivers of controllability [67], a great number of studies focused on modeling [68], believing that the situation would be better than it planned to be. However, the pandemic did not turn out as expected in the planning, and this has led to some critical thinking about the anticipations resulting from this atmosphere of preparedness. In this case, studies tried to frame a new preparedness plan by comparing existing ones from different countries, hoping to strengthen coordination in future pandemics [69]. Therefore, the late stage (2016–2019) went from "in-pandemic" to "pre-pandemic". While the research concerns in COVID-19 (2020–2022) showed up very differently as they represented a series of ideas and goals for the future city. A total of 71 papers discussed how to minimize the impact of disease and the chance of future pandemics, occupying 72% of the database. Part of the reason for this difference lay in the disparity in the scale of the crisis caused by H1N1 versus COVID-19. COVID-19 had an estimated over 6 million deaths worldwide as of today [70], while H1N1 caused less than 1 million deaths worldwide [15]. According to the time of declaration and cessation of the global health emergency by WHO, H1N1 lasted 16 months, while COVID-19 lasted 39 months [1]. Thus, just as most assessors claimed that the 2009 pandemic was mild [16]. A comparison of empirical case studies from the two

periods [71,72] showed that both adopted consistent community mitigation measures under IHR guidance. However, given the differences between the coronavirus and the influenza virus, school closures were used more frequently and effectively in the H1N1 pandemic as the susceptible population was mainly children and young people aged 5–45 years [34]. In contrast, even with stricter isolation, quarantine, zoning, and city-scale lockdown in some cases in the COVID-19 pandemic, the spread could hardly be slowed down as the transmission was more concealed, diverse, and faster [73]. In this context, the academic community was increasingly concerned not only with controlling or mitigating outbreaks but also with tracing health problems back to their origins. Furthermore, in urban planning, 'rethinking' is in vogue. Health problems in particular have been found to arise at the local level from uncontrolled urbanization, fragmented settlement patterns, unsustainable production and consumption patterns, poor air quality, loss of biodiversity, unsafe food systems, etc., all of which have a significant impact on the well-being of urban dwellers [61]. It is no longer permitted to urbanize without careful consideration of our impacts on nature and life. Therefore, it was COVID-19 that triggered a new understanding of the relationship between human beings and the environment and spurred a plethora of predictions on long-term, radical urban planning changes [74], shaking up cities from their fundamental form to their mode of operation towards sustainable development with unprecedented intensity. Hence, the keywords in COVID-19 had a "post-pandemic" feature even when we were all still in the mire of it.

For this reason, research during the H1N1 period focused on the operational aspects of preventing and reducing the spread of infectious diseases because it was "pre-pandemic" and "mid-pandemic" related, and urban theories supported it very little. In contrast, the COVID-19 pandemic research focused more on the "post-pandemic" dimension, and only then was it integrated with multiple urban theories, which explains why more conceptual studies emerged during this period than with H1N1.

4.2.2. Change-2: From Global, National, to Local

As seen in Section 3.3.1, most of the H1N1 studies were conducted on a global, national, or regional basis, with very few specifically studying cities. During the COVID-19 period, most of the study subjects became individual cities.

Although mathematical and computer models were first used worldwide for emergency response to the risk of major infectious diseases during the H1N1 pandemic. However, the main problem was the lack of real-time data available at all times [75]. Retrospective articles from the H1N1 period indicated that the difficulty of high-performance computing and obtaining real-time data both impacted the quality of pandemic predictions [76], but the silver lining was that collaboration between modelers and policymakers was facilitated, which successfully demonstrated the importance of evidence-based decision making. By the time of the COVID-19 pandemic, innovations in artificial intelligence, big data, GIS, GPS, and other geospatial technologies offered the possibility of real-time monitoring and management. Data were collected not only from integrated national information systems but also by recruiting civil society participation and self-reporting [77,78]. Such multi-channel data sources gave local managers a more adequate and specific basis for decision making and a more flexible strategy to combat the pandemic. In addition to the technical progress, the theoretical development was traceable. For example, "Weberian city", one of the key words of urban theory found in the H1N1 study, is from the retrospective article of Hoffman, LM (2013) [79]. By criticizing the 'all-hazards emergency preparedness and pandemic response' in the United States during H1N1, the revival of Weber's urban structure was advocated by underlining the importance of locality as a first line of defense. A new section on community engagement was added to the 2017 community mitigation guideline by the CDC (Centers for Disease Control and Prevention), drawing lessons from the 2009 H1N1 pandemic, to emphasize that timely and effective use of NPIs depends on community acceptance and active participation [34]. Similarly, the new guidance document issued by WHO [80] revised global pandemic phases and

their uncoupling with national and local actions and increased the importance of flexibility at the local level. Hence, in the COVID-19 period, the significance of local adaptation as an essential aspect of the planning process was widely acknowledged throughout the COVID-19 era. The frequent emergence of "tactical urbanism" and "informal urbanism" also showed the significance of bottom-up participation. Likewise, in the research narrative related to "community resilience", it was similarly implied that local communities, including citizens, had actually been empowered with more autonomy. The experiences of Wuhan [81], Huangzhou [82], Urmia [83], Chicago [52], and Lombardy [84] proved that building urban resilience cannot succeed without public participation, which is also in line with the emphasis in the latest pandemic guidelines in 2021 [20] on building on the existing capacity development plan and mobilizing "people" as the first respondents. Multi-sector, multi-level, and multi-stakeholder engagement minimizes reliance on technocratic bureaucracy and eliminates oversimplified assumptions about social and political dynamics, as local governments and local institutions can support knowledge in all its forms—including indigenous, local, and traditional knowledge—in response to global needs while acknowledging their specificity.

Moreover, this change in the scale of research was also reflected in economic development. The relevant studies of COVID-19 confirmed that the capitalist model of development was very inflexible in the event of a pandemic, with its rigidity and stubbornness making it difficult for most cities to prepare for adversity [85]. In particular, the prevalence of global supply chains made cities extremely vulnerable to sudden shocks, cutting off their supplies of food, basic necessities, and means of production and bringing commercial enterprises to a halt [86]. In such a scenario, there has been a significant change in the mindset and priorities of governments. For now and in the future, to deal with pandemics and comparable crises, an economy that balances global and local transactions and a transformation to more local supply chains that increases self-sufficiency are needed. Instead of relying heavily on economic globalization, the economy should first be rooted in meeting the basic local needs of cities, strengthening investment and construction in infrastructure, restoring local ecosystems, and building supportive community networks. Furthermore, to develop new directions and pathways for economic growth, with a focus on the transition to a green recovery and a knowledge-based economy.

In general, the transformation of governance patterns in this decade could not have been possible without the technical and theoretical preparations made during the H1N1 period. Robust data regulation, flexible multi-level governance, and revitalization of the local economy will be important tools for cities to deal with pandemics in the future.

4.2.3. Change-3: The Prominent Role of Urban Built Environment

The number of studies on the theme of post-pandemic planning in the COVID-19 period increased dramatically compared to the H1N1 period (see Table 2). As more empirical cases demonstrate the relationship between the urban-built environment and confirmed cases [55,87], the research interest in this field is very much focused on the "built environment", from land use to building density, from infrastructure layout to green space, all of which can only be changed over long periods of time. This was thus beyond the reach of the "in-pandemic" and "pre-pandemic" periods of H1N1 concern. It was the focus on the "post-pandemic" nature of research in the COVID-19 era that initiated the tremendous power of the urban-built environment to accelerate the return of urban planning and design to the topic of public health.

During the COVID-19 period, the direction of research on the urban-built environment has undergone considerable change. Initial research focused on how the coronavirus might affect the present shape of cities, in particular the possible secondary effects of social distancing, lockdowns, and border closures, which were widely used in the early years of the pandemic [63]. These effects will diminish or even vanish as pandemic policies are relaxed. However, later studies were linked to the main urban theories under the theme of post-COVID planning, suggesting that the pandemic has had a long-term impact on

the built environment, just as it was mentioned in change-1. Firstly, the built environment is related to smart cities. Due to the successful application of smart technologies during the COVID-19 period, many of the daily activities of the residents shifted from offline to online, and as a result, a very different lifestyle was developed after the pandemic than before [63,88]. In the midst of the pandemic, single-function houses were unable to meet new living patterns such as home offices and home schooling, and most settlements were unable to absorb the massive logistical burden of the proliferation of online purchases. The mindset and needs of the public changed dramatically, especially after a long period of isolation, creating a strong desire for blue-green infrastructure [89], outdoor spaces [90], and the introduction of natural elements, including sunlight and plants, into the residential environment [91]. These will contribute to a positive change in the built environment of the city. For example, the design of less resource-intensive but more resilient human settlements, the enhancement of further functional composites in buildings, the increased use of nature-based solutions, and the protection of the environment. Secondly, the built environment is related to sustainable development. A series of critical reflections on urban land use, housing density, transportation structure, and food supply during the COVID-19 period not only served to reduce the spread of the virus but also helped to increase resilience, improve air quality, and reduce energy demand, thus increasing the sustainability of the built environment and opening up a green path for post-pandemic urban development. Finally, the built environment is associated with vulnerability. Inequitable allocation of urban public space, services, and other resources was considered to be an important cause of vulnerability [40,52]. Since unreasonable spatial distribution has a long history [65], it has become a persistent problem that hinders health equity. The city of the future should be shaped by spaces that are sufficiently compact and connected while at the same time guaranteeing affordable housing and easily accessible public services, which can help to remove the socioeconomic barriers reflected in the pandemic and achieve environmental justice. Consequently, there was an endless stream of research exploring new urban models or forms. Furthermore, highly granular urban information and intelligence technologies provided researchers with a perfect testing ground for the incubation and application of theoretical blueprints [60,63,66]. The research results of empirical combined modeling were particularly prominent during this period, which accelerated fundamental changes in the methodological and technical approach to urban planning and design.

From the above process, it is clear that the studies under the post-COVID planning theme have different emphases, but in the end, they all intersect in the built environment dimension. In the near future, a new paradigm of urban planning and design is expected to eventually emerge that will collectively drive cities toward equity, inclusion, smartness, resilience, and sustainability.

5. Conclusions

One of the crucial findings of this research is the identification of urban theories that work at minimizing the impact of pandemics on urban planning, which include: (1) “resilience”, (2) “sustainability”, (3) “smart city”, (4) “vulnerability”, (5) “healthy city”, (6) “15-min city”, (7) “tactical urbanism”, (8) “temporary urbanism”, (9) “informal urbanism”, (10) “Compact city”, (11) “livable city”, and (12) “Weberian city”, of which the first four are the most widely used and most important. Considering that many urban theories already overlap, such as “resilience” and “sustainability”, “resilience” and “smart cities”, “resilience” and “vulnerability”, etc., this offers great potential to break down barriers between theories and build a more comprehensive network of theories. Further research is needed to continue assessing the abilities of various urban theories in the context of pandemics as well as exploring how they can coordinate with each other.

Another important finding is the three main changes in urban planning’s response to the pandemic from H1N1 to COVID-19: from a focus on ‘in’ and ‘pre’ the pandemic to a focus on “post-pandemic”, from global and national to local, and from the absence of an urban-built environment to a return to ‘healthiness’ in urban planning and design.

From H1N1 to COVID-19, the changes in urban responses to the pandemic have been dramatic, ranging from technological approaches to spatial and temporal scales. Although inseparable from the theoretical and technical foundations of the H1N1 period, we can glimpse a return to the theme of public health and a trend toward increasingly systematic, localized, and intelligent urban planning in pandemics.

The experience of H1N1 and COVID-19 confirms that the more sustainable, resilient, smart, and inclusive a city is, the better it will survive the next round. Future recommendations for city managers, planners, and other local actors include, firstly, highlighting the participation of multiple subjects and opening up channels for information communication to provide ways for the public to intervene in urban governance. Secondly, high priority should be given to economic diversification. Additionally, encourage cities to increase their self-sufficiency and be rooted in the development of infrastructure services and ecosystem protection. Thirdly, strengthen the planning and design of multi-scale "city-community-buildings" spaces to protect the health of residents and adapt to new lifestyles. Pay special attention to affordable housing and the distribution of infrastructure to protect the interests of vulnerable groups and deepen health equity.

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