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The Impact of the COVID-19 Pandemic on Architectural Space Needs

COVID-19 Pandemisinin Mimari Mekân İhtiyaçları Üzerindeki Etkisi

Halit Coza[1]

Öz

Bu makale, COVID-19 pandemisinin mimari ve kentsel tasarım üzerindeki dönüştürücü etkisine odaklanarak, mimarlar, kentsel planlamacılar ve politika yapıcılar için pandemi sonrası ortamda yol gösterici önemli perspektifler sunmaktadır. Nitel bir yaklaşım kullanarak, literatür taraması ve gözlemlere dayalı analizle, çalışma pandemilerin tarihsel örneklerini inceleyerek kentsel tasarımı şekillendirmede oynadığı rolü ortaya koymakta ve COVID-19 tarafından tetiklenen belirli değişikliklere odaklanmaktadır. Bulgular, "geçiş alanları"nın tanıtılması, antibakteriyel malzemelerin entegrasyonu, uzaktan çalışma ve eğitimdeki artış, doğal ışık ve açık alanların önemi, toplu alanlarda sosyal mesafe adaptasyonları, yeşil alanlara vurgu, evlerin çok işlevli alanlara evrimi, felaket senaryoları için düşünceler ve akıllı bina sistemlerinin entegrasyonu gibi çeşitli yönleri içermektedir. Bu çalışma, pandeminin mimari ve kentsel paradigmalara olan çok yönlü etkisini vurgulayarak dirençli, uyarlanabilir ve sürdürülebilir inşa çevreleri oluşturmak için bir rehber sunmaktadır. Gelecekteki araştırma fırsatları da belirlenmiş olup, uzun vadeli toplumsal etkilerin, kültürel bağlamlarda küresel uygulamanın ve akıllı teknolojilerin mimari çerçevelerdeki evriminin keşfini teşvik etmektedir.

Anahtar Kelimeler: COVID-19, Mimari Adaptasyonlar, Kentsel Tasarım, Sağlık ve Güvenlik

ABSTRACT

This article delves into the transformative impact of the COVID-19 pandemic on architectural and urban design, offering essential insights for architects, urban planners, and policymakers in navigating the post-pandemic landscape. Employing a qualitative approach through a literature review and observational analysis, the study explores historical precedents of pandemics shaping urban design and scrutinizes the specific changes triggered by COVID-19. Findings encompass diverse facets, including the introduction of "transitional spaces," the integration of antibacterial materials, the surge in remote work and education, the significance of natural light and open spaces, adaptations in public spaces for social distancing, the emphasis on green areas, the evolution of homes into multifunctional spaces, considerations for disaster scenarios, and the incorporation of smart building systems. This study underscores the multifaceted nature of the pandemic's influence on architectural and urban paradigms, providing a roadmap for creating resilient, adaptable, and sustainable built environments. Future research opportunities are identified, encouraging exploration of long-term societal impacts, global implementation across cultural contexts, and the evolving role of smart technologies in architectural frameworks.

Keywords: COVID-19, Architectural Adaptations, Urban Design, Health and Safety

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Introduction

Since the beginning of 2020, the COVID-19 pandemic has had a profound impact on both social life and the way-built environments are used, transforming them in unprecedented ways. COVID-19 is not the first pandemic the world has faced, and it is not the deadliest among them (Feehan and Apostolopoulos, 2021). However, it has become one of the most widespread pandemic diseases globally since its emergence (Assefa et al., 2021).

Several anthropogenic activities characteristic of the modern era have played a significant role in creating this situation alongside the virus's high transmission rate. These include rapid population growth, global population mobility, climate change, plastic pollution, habitat destruction leading to species extinction, industrial agriculture, rapid resource consumption, and unplanned urbanization (Rice, 2020).

Throughout history, pandemic diseases have often served as pivotal moments in shaping urban spaces, especially in densely populated areas. Changes in the built environment and, consequently, in human lifestyles have been made possible through innovations in construction systems and spatial organization aimed at enhancing the quality of life. These changes have included the development of drainage and clean water distribution systems (Belfiglio, 2017; Bruun, 1991; Pinheiro and Luís, 2020), the creation of extensive public spaces and transportation networks within cities, and the establishment of large green areas in city centers (Jordan, 1995; Megahed and Ghoneim, 2020; Pinheiro and Luís, 2020; Szczygiel and Hewitt, 2000). Additionally, considerations such as daylight, clean air circulation, and the incorporation of design elements like balconies, terraces, and rooftop gardens that promote indoor-outdoor connectivity have been influenced by pandemics threatening human and societal health (Budds, 2020; Megahed and Ghoneim, 2020; Pinheiro and Luís, 2020). The impact of COVID-19 is evident in residential planning and design, particularly influencing the residential environment, building space, planning areas, and traffic and community management (Chen et al., 2023).

The term "built environment" broadly refers to human-made living spaces. This article aims to examine how the elements influencing built environment design have been affected by the pandemic and how these changes, when combined, will cumulatively bring about transformations in the built environment. Through a qualitative approach, this study explores the potential changes, both physical and conceptual, in the built environment that will arise following the COVID-19 pandemic. The methodology involves a literature review and observations of changes in the built environment throughout the pandemic.

In this context, we first examine the transformations brought about by pandemics in urban design and architecture throughout history. Subsequently, we analyze publications and studies on the changes resulting from the COVID-19 pandemic following its declaration as a "pandemic" by the World Health Organization in 2020. Based on this data, we outline the concepts, approaches, and possible implications that are likely to come to the forefront in post-pandemic-built environment design.

The impact of the COVID-19 pandemic on daily life and the physical infrastructure.

Transitional Spaces and Hygiene Areas

During the pandemic, new concepts like "transitional spaces" and "intermediate spaces" have emerged as we have become more conscious of the need for hygiene barriers and sterilization zones before entering main living areas, particularly in residential settings. Residential entryways have seen

the emergence of hygiene barrier areas where daily essentials and clothing from outside can be disinfected. When designing new spaces, user demands and needs now include the provision of these areas. Additionally, the design of entrance foyers with easy access to balconies has become a user-requested feature. Requests for wet areas near the entrance have also become a part of user requirements. Furthermore, the need for a certain amount of wet area space per person has become a consideration in the design process.

Materials used in hygiene areas are increasingly expected to have antibacterial and antimicrobial properties. These developments aim to enhance hygienic conditions to prevent the spread of infections and microorganisms. The use of materials with antibacterial and antimicrobial properties has been adopted, particularly in healthcare facilities, hotels, restaurants, public transportation, and public spaces, to elevate hygiene standards and protect human health. Technological products like touchless faucets, sensor-controlled doors, and automatic soap dispensers minimize the risk of germ transmission by offering hands-free usage. Additionally, antimicrobial surfaces are produced with special coatings or materials that inhibit the growth and spread of microorganisms contacted by these surfaces. These materials contribute significantly to hygiene by reducing the lifespan of bacteria and viruses on surfaces.

The use of antibacterial and antimicrobial materials in hygiene areas has become an increasingly adopted approach to control infections and preserve human health. These technologies contribute to raising hygiene standards in various aspects of daily life and in the healthcare sector. When distinguishing between the pre-pandemic, pandemic, and post-pandemic periods, it can be observed that the post-pandemic period has brought about a greater need for spatial dividers and separators. The desire is to create divisions within spaces while avoiding permanent alterations, promoting adaptability, and leading to more sustainable spatial requirements.

Remote Work and Education

The use of information technology in the workplace has given rise to flexible working models, with the most notable outcome being the concept of remote working, commonly known as "working from home" or "telecommuting." Remote working involves the use of information technology to perform all or part of a job outside of the traditional office environment (Kavi and Koçak, 2010). Many businesses encourage remote work to reduce costs and tap into a qualified workforce from different locations. In remote working models, employees have the flexibility to choose their work location (Demirbilek, 2007).

Flexible working models such as remote work, home office work, and telecommuting gained increased attention during the COVID-19 pandemic. To mitigate the risk of virus transmission, remote and home-based work became a new business model during the pandemic. These models were implemented in various ways worldwide (Akça and Tepe Küçükoğlu, 2020). In Turkey, with the first coronavirus case reported in March 2020, measures were taken to create a safer working environment for businesses and ensure its sustainability (Hasanhanoğlu, 2020). As a result, some university departments and programs can now offer education entirely or partially through remote learning. Some companies have adopted a fully remote work arrangement, which may continue post-pandemic. This alternative way of working, observed in the business world, has led to changing spatial needs both in office spaces and in employees' residential areas.

Individuals who spend their workdays at home while also attending to essential or social needs must be able to perform these two activities in different spaces within their homes. This requirement goes beyond technical and practical needs and can have psychological effects as well. Therefore, it is clear that contemporary residential designs need to incorporate hygiene areas, workspaces, and an

increased demand for open spaces. Additionally, the need for a quiet and isolated space for remote meetings or classes, whether for oneself or other family members, has become a pressing consideration in modern home design.

Natural Light and Open Spaces

The pandemic occurred during a period when people spent less time outdoors due to lockdowns and restrictions, potentially leading to issues such as vitamin D deficiency. Vitamin D may have a protective effect against enveloped viruses and could reduce mortality rates from viruses like COVID-19. Research shows that sunlight stimulates the production of vitamin D and has positive effects on the immune system (Beard et al., 2011; Hedlund et al., 2020). Therefore, individuals deprived of sunlight due to confinement in their homes may weaken their immune systems, making them more vulnerable to viruses.

Hobday and Dancer (2013) argued that open air and clean air are essential for patient care and preventing the spread of viruses. For instance, during the 1918 influenza pandemic, patients cared for in open-air environments had a higher survival rate compared to those in conventional hospital settings. Consequently, the pandemic has emphasized the importance of incorporating open spaces and natural light into the design of living spaces. This design approach can reduce stress levels and enhance the immune system of users (Bereitschaft and Scheller, 2020; Soderlund and Newman, 2015).

In homes, open spaces such as balconies, courtyards, terraces, rooftop gardens, and gardens should be considered as important as indoor spaces. These areas also provide an opportunity to connect with nature. Additionally, transparent openings and natural light control elements can allow more daylight to enter indoor spaces, which can have positive effects on human psychology. These design features can also reduce the formation of bacterial colonies in enclosed spaces.

In conclusion, providing more natural light in new buildings is important for both physical and mental health. Natural light can help prevent the spread of viruses and positively impact overall human health. Therefore, designing living spaces with ample access to natural light and outdoor areas should be a priority, as it contributes to the well-being and resilience of individuals, especially in times of health crises like the COVID-19 pandemic.

Hygiene Protocols

Post-pandemic, commercial businesses and offices have introduced various hygiene protocols, necessitating design considerations in spatial planning. Globally, due to COVID-19 measures, remote work has prompted some managers to make long-term adjustments. Some managers have realized that it's not necessary for hundreds or thousands of people to work together in large buildings. During the pandemic, they observed that work could continue smoothly through remote work, leading to reduced costs. In sectors where remote work isn't feasible, there's a need to reconfigure office spaces. Instead of crowded open offices or shared workspaces, offices are now being designed with more flexibility, offering options for staggered work schedules and implementing measures to ensure the safety and well-being of employees returning to the workplace. Offices are seeing changes such as wider corridors, more doors, additional walls, and increased elevator capacity. Meeting rooms can be expanded using sliding partition doors based on the number of participants. Ventilation systems are being improved for better air circulation. Desks are spaced at least 2 meters apart to maintain physical distancing. Some architecture firms have already started designing various solutions to address these requirements (Ak, 2020).

Digital Infrastructure

The rising trend of remote work has introduced new challenges, such as the need for dependable internet connectivity and the establishment of efficient home office setups. Homeowners are now actively seeking solutions to create practical and comfortable workspaces within their residences. This has given rise to a burgeoning home office design industry, where professionals offer their expertise to assist individuals in crafting the ideal work environment at home. The pandemic has underscored the immense significance of digital connectivity. To curb the spread of rapidly spreading diseases, it became imperative to limit physical interactions, underscoring the vital role of digital communication. In this context, the development and widespread adoption of high-speed and reliable digital infrastructure take on utmost importance. These infrastructures are indispensable in ensuring easier and swifter access across various domains, encompassing remote work, education, and healthcare services. Even as the immediate effects of the pandemic recede, the pivotal role of digital connectivity in scenarios involving other emergencies is likely to remain a lasting necessity.

Public Spaces

During the pandemic, the usage of indoor public spaces decreased significantly, while the utilization of outdoor public areas increased worldwide compared to the pre-pandemic period, creating a higher demand for such spaces (Our World in Data, 2021). The reduced use of indoor public spaces, along with restrictions on social activities such as theaters and cinemas, has made urban recreational areas more valuable as they remain one of the few places for social interaction. Large city parks and urban forests play a crucial role in meeting the need for clean air in cities. However, the pandemic has highlighted the importance of smaller neighborhood-scale parks within walking distance of residential areas (Koca and Tutal, 2021; Partigöç and Turhan, 2020; Ugolini et al., 2020). Distributing green spaces gradually and equitably throughout the city is essential to decentralize the urban environment. This approach reduces the need for city dwellers to travel within the city to access green spaces, thus minimizing population mobility. Therefore, ensuring the distribution of green spaces in urban areas in line with social justice and converting urban niches between neighborhoods into green spaces for more effective use is crucial for a healthy built environment. The presence of green spaces near residential areas, easily accessible, and even visible from homes, will have a positive impact on individuals' physical and psychological health.

In public spaces like parks, gardens, squares, courtyards, redesigning to accommodate social distancing criteria has become necessary. Design considerations now focus on creating layouts that allow people to come together while adhering to social distancing requirements. Designing layouts that enable appointment systems in public indoor spaces, addressing people's spatial needs during waiting periods, automatic door systems, and seating arrangements during waiting or transaction processes are being reconsidered to minimize physical contact and communication.

The concept of physical distancing in public spaces is not limited to the pandemic but contributes to various factors such as public health, comfort, privacy, and personal space regulation. This concept aids in controlling diseases before and after pandemics, regulating social interactions, and enhancing personal comfort. Furthermore, it reduces stress, making individuals feel calmer and safer. Therefore, the concept of physical distancing should continue to be a priority in the design of public spaces. In common areas and new building designs, hygiene criteria have gained importance from a design perspective. Wet areas have necessitated a reevaluation of the distance concept in wet space layouts due to the need for queuing. It is appropriate for materials to have properties that do not retain microbes, dirt, bacteria, etc., and elements and materials that will be touched by hands should be designed and used with sensor-based solutions in mind.

Green Areas

On the urban planning level, it is feasible to boost productivity by reducing the density of individuals in various spaces. Urban squares and communal areas serving the broader community, as well as social spaces, should undergo diversification. To ensure the safe movement of urban populations during pandemics, elements like squares, green areas, and streets must offer ample room. Furthermore, in regions where access to green spaces is challenging, like industrial zones, offices, and schools, efforts should be made to expand these spaces as much as possible. It could be beneficial to multiply and organize the locations and layouts of shopping malls, supermarkets, transportation hubs, and essential service providers, taking into account ease of access from individuals' residences. This approach can help ensure safe social circulation both during and after pandemics, reducing the concentration of people in any given space.

Throughout the pandemic, people's desire for green and open spaces has grown as they spent more time confined within enclosed private quarters. Those fortunate enough to have gardens made more use of them, while those with balconies and terraces attempted to satisfy this need by improving these spaces. A significant portion of the population residing in small, high-rise apartments began to question the absence of such spaces in their homes even more. The concept of creating alternative green spaces at the residential level, such as "rooftop gardens," emerged as a solution for pandemics and similar scenarios. The idea of utilizing rooftops as gathering areas, shared social zones, and landscaped environments in apartment living gained prominence. In densely populated areas with limited access to traditional green or garden spaces, rooftops have the potential to fulfill this requirement.

Multifunctional Spaces

The pandemic has transformed homes into multifunctional spaces, not only for shelter but also for work, education, and leisure (Ak, 2020). Each of these activities has different spatial requirements. Therefore, designing spaces with flexibility that allows for different functions and can quickly adapt to various usage patterns and user numbers is essential for user satisfaction (Klein, 2020). In this regard, the application of movable partition systems that can be used within the space to create flexible and adaptable areas can be considered a solution. Post-pandemic, especially in residences, it has been observed that people have a significant need for home offices and dedicated rooms for managing their work from home. Therefore, using movable panel furniture to create small spaces with different functions when needed within the space can be a valuable approach.

Moreover, in situations where small and narrow spaces need to accommodate various functions, a solution can be developed by using multifunctional furniture. These types of furniture designs allow for different uses and multiple functions within a limited space. For example, a single piece of furniture can serve as both a workspace and a sleeping area through a foldable arrangement. This enables the creation of spaces that offer multiple functions with minimal furniture use in small areas. With many people working remotely from home, the need for a dedicated workspace has become more critical than ever. As more people prefer to work from home, it has become evident that the traditional home setup is no longer sufficient to meet the needs of modern workers. In response, many homeowners are converting spare bedrooms or other areas in their homes into home offices. This has led to an increased demand for home office furniture such as desks, chairs, and bookshelves.

Disaster Scenarios in Architecture Design

Living through the Covid-19 pandemic has underscored the importance of adapting spatial designs to a range of disaster scenarios, not only limited to pandemics but also encompassing various natural

disasters that our world faces today. For example, in the midst of an ongoing earthquake situation, universities explored the possibility of reverting to the remote learning methods that were tested during the pandemic as a potential solution. This highlighted the need for educational institutions, including schools and universities, to be designed with greater flexibility to accommodate diverse needs and requirements, including the potential for part-time use during both pandemics and natural disasters. The adoption of remote learning as an educational method also emphasized the opportunity and necessity for educational facilities to cater to a wide array of needs.

The Covid-19 pandemic has disrupted the utilization of spaces in their traditional configurations, leading to the emergence of new requirements and utilization patterns, which, in turn, demand adjustments in spatial layouts. Throughout the pandemic, existing spatial arrangements were reevaluated, and the need for new spatial extensions became evident. These additional spaces can be described as intermediary areas that serve as secure zones at specific points while also functioning as buffer zones. Intermediary spaces seek to strike a balance between indoor and outdoor environments, representing an architectural response to the increased emphasis on isolation during the pandemic. These intermediary spaces have become an integral part of the existing spatial framework.

Social Distance

COVID-19 primarily spreads through close contact, typically within a range of 2 meters (approximately 6 feet), and via face-to-face interactions lasting 15 minutes or longer. Moreover, in crowded and poorly ventilated indoor environments, the virus can be transmitted through the air, especially when individuals spend extended periods in such settings. Essentially, in locations with inadequate air quality, the virus can potentially spread over distances exceeding 2 meters (Cevik et al., 2020). Research has also indicated that the virus can be transmitted through wastewater systems and microorganisms present in airborne dust particles (Qu et al., 2020). Consequently, the initial measures taken to reduce the spread of the pandemic have centered on practices like social distancing, isolation, mask-wearing, quarantine, and lockdowns.

Architectural designs that promote social distancing aim to enable individuals to move safely without close physical contact (Alhusban et al., 2021). The significance of maintaining social distancing has grown in the post-COVID-19 era, prompting architectural alterations. These alterations might involve the reconfiguration of indoor spaces within buildings and the redesign of areas where people move. Within indoor environments, adjustments can be implemented to prevent individuals from coming into close proximity to one another.

Within indoor environments, it is possible to create broader corridors and pathways, enabling individuals to move comfortably without the need for close contact. This design adaptation not only promotes unhindered movement while adhering to social distancing but also enhances the infrastructure for emergency situations and evacuations, making indoor spaces more practical and secure. The significance of outdoor spaces has gained prominence in architectural endeavors amid the COVID-19 pandemic. Outdoor areas have become havens for safe gatherings, leisure, and social interaction. Consequently, architects and designers are placing a greater emphasis on integrating expanded outdoor space utilization into their post-pandemic projects.

Navigating the Built Environment in a Post-COVID-19 Era

Ventilation Systems

In indoor settings, the role of ventilation systems has gained heightened importance in the effort to prevent the spread of infections. To facilitate cleaning and disinfection, materials that possess easy-to-clean and antibacterial properties are preferred for shared spaces.

The COVID-19 virus can exist in the air as aerosols, underscoring the critical need for the use of high-efficiency filters like MERV-13 filters in ventilation systems. Ensuring adequate air circulation within enclosed spaces plays a pivotal role in mitigating the transmission of the COVID-19 virus. Ventilation systems must be designed to provide sufficient air exchange based on the indoor space's volume. It's essential to reevaluate and potentially reconfigure existing ventilation systems to align with post-pandemic conditions. Previous ventilation designs may have unintentionally facilitated virus transmission, making it imperative to closely monitor the filters, cleaning, and disinfection processes of ventilation systems in the post-pandemic era.

Several recommended technologies have emerged for ventilation systems in the post-pandemic landscape, including HEPA filters, UV-C radiation, and ozone treatments. HEPA filters are effective at capturing and filtering viruses and microorganisms present in the air (Curtis, 2021). UV-C radiation is employed to neutralize airborne viruses, and ozone treatment serves as a method to eradicate microbes and viruses from the air (Criscuolo et al., 2021). These technologies collectively contribute to enhancing indoor air quality, promoting safety in the post-pandemic world.

Antimicrobial Materials

The COVID-19 pandemic has placed significant emphasis on the cleanliness and hygienic properties of building materials. During this period, material manufacturers associated with the construction industry have focused on improving the antimicrobial properties of their products, and this has encouraged experimental academic research. Especially in pandemic conditions, the ease of cleaning materials used inside buildings serves the goal of reducing infection risk.

Research has shown that the SARS-CoV-2 virus can remain viable for 48 hours on stainless steel surfaces, 72 hours on plastic surfaces, 24 hours on cardboard, and only 4 hours on copper surfaces (Brownell, 2020; Van Doremalen et al., 2020). In this regard, copper, and its alloys (bronze, brass, etc.) are considered antimicrobial materials due to their ability to disrupt cell functions. Materials that shorten the virus's viability on surfaces, such as door handles, bathroom and kitchen countertops, and wall surfaces, may be preferred in areas with high user contact. Silver, another metal with known antimicrobial properties, can be used by incorporating it into building materials in nanoparticle form, even though it is not directly affordable. Additionally, materials such as glass, ceramics, and steel can be given antimicrobial properties by adding photoactive pigments to them (Spalidoro, 2020).

The ability of the COVID-19 virus to survive on surfaces has increased the importance of surface materials used within buildings. In this context, hard-surfaced materials (e.g., metal, glass, laminate, epoxy-coated floors, ceramic tile flooring) or antimicrobial coatings used for covering surfaces play a critical role in combating the pandemic. Considering that the COVID-19 virus can settle into microscopic crevices on surfaces, it is essential for interior finishes to have a smooth and homogeneous structure. Moreover, the use of antimicrobial coatings can provide a measure to reduce the risk of infection. In this regard, a scientific and technical approach contributes to the building industry offering more hygienic and safe spaces in the post-pandemic world.

Smart Building Systems

Many infectious diseases, including COVID-19, primarily spread through contact with contaminated surfaces (Dietz et al., 2020; Qu et al., 2020). Especially in spaces with high user circulation, the use of touchless control systems as much as possible will not only help protect public health but also make the built environment more universally designed for equal access by everyone (Story et al., 1998). To achieve this goal, elements of the built environment that serve a large number of users, such as elevators, hotel room keys, control buttons, and public doors, can incorporate voice control systems and applications that can be used via smartphones (Zamfir et al., 2021; Wainwright, 2020).

The use of digital technologies in architectural designs post-COVID-19 can contribute to making buildings safer and healthier. Smart building systems can help make buildings more efficient and sustainable. These systems can manage functions such as automatic lighting, heating, cooling, and ventilation, reducing human contact and creating a healthier environment. Sensors can measure indoor air quality, humidity, temperature, and other important factors, contributing to maintaining a healthy environment within buildings. Additionally, sensors can monitor the energy consumption of buildings and enable energy savings. Artificial intelligence can be used to enhance building security. For example, AI-based cameras can detect infected individuals using technologies like facial recognition and temperature scanning, making buildings safer (Zamfir et al., 2021; Wainwright, 2020).

Conclusion

In conclusion, this study aimed to investigate the multifaceted impact of the COVID-19 pandemic on the built environment, examining shifts in architectural and urban design. The significance of the work lies in its comprehensive analysis, offering insights for architects, urban planners, and policymakers navigating the post-pandemic landscape. The findings contribute to the discourse on creating resilient and adaptable living spaces prioritizing health, well-being, and sustainability. The study's results encompass diverse aspects, including hygiene considerations, remote work and education, the integration of natural elements, disaster scenarios, social distancing, ventilation systems, antimicrobial materials, and the role of smart building systems. Each objective reveals adaptations and considerations crucial for shaping future architectural practices. The study aligns with existing literature on pandemics' historical impact on urban design and contributes to ongoing research on sustainable and resilient built environments. Future research opportunities include exploring long-term societal impacts, global implementation in diverse cultural contexts, and the evolving integration of smart technologies into architectural frameworks.

Compliance with Ethical Standard

Conflict of Interest: *The author(s) declare that they do not have a conflict of interest with themselves and/or other third parties and institutions, or if so, how this conflict of interest arose and will be resolved, and author contribution declaration forms are added to the article process files with wet signatures.*

Ethics Committee Approval: *In this article, ethics committee approval is not required, and a consent form affirming that a wet-signed ethics committee decision is not necessary has been added to the article process files on the system.*

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