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The impact of epidemics and pandemics on architectural and urban transformations of cities

Abstract. The aim of study was to identify and systematise architectural and urban transformations of cities, urban engineering infrastructure and the residential environment that occurred in response to epidemics and pandemics. The research methodology was based on an interdisciplinary approach that combined historical-retrospective, comparative, and spatial-analytical methods with the use of contemporary urban and epidemiological studies. The study showed that from the earliest water supply and sewage systems in the cities of the Ancient East and Antiquity to the comprehensive sanitary reforms of the 19th century and modernist ideas of the "healthy city", architectural and planning solutions have been consistently used as a tool to counter the spread of infectious diseases. The article provided a historical and analytical overview of the transformations of urban space under the influence of epidemics, as well as focusing on the modern stage associated with the COVID-19 pandemic. It showed that the modern stage had been characterised by a shift in focus from basic sanitary and engineering solutions to the morphological parameters of the living environment, in particular the density and number of storeys of buildings, the configuration of common spaces and the effectiveness of natural ventilation. Particular attention was paid to the analysis of the spatial parameters of residential buildings that indirectly influenced epidemiological risks, in particular the number of storeys and density of buildings. Based on modern interdisciplinary empirical studies, statistically confirmed correlations between increased density, number of storeys of housing and more intensive spread of infection were analysed. The role of aerosol transmission routes through common engineering systems of multi-storey buildings was emphasised. Design-relevant conclusions were summarised regarding acceptable levels of space utilisation intensity, as well as the role of open and semi-open spaces in reducing the risk of infection transmission and psychological stress during prolonged quarantine. Emphasis was also placed on the importance of effective natural and mechanical ventilation, the organisation of air exchange in common areas (stairwells, corridors, lift halls) and the prevention of stagnant air zones. The practical significance of the work lies in the formation of architectural and urban planning

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recommendations aimed at increasing the pandemic resilience of the living environment, in the range of "district – multi-apartment residential building"

Keywords: viral infection transmission; residential environment; engineering infrastructure; building height; pandemic resilience; health architecture

INTRODUCTION

The COVID-19 pandemic (2019-2025), caused by the SARS-CoV-2 virus, brought renewed attention to the relationship between epidemics and architectural and urban planning solutions as key non-medical mechanisms for containing the spread of infectious diseases. In the context of global urbanisation and high population mobility, cities have once again found themselves at the centre of epidemiological risks, which has led to a growing interest in the historical experience of creating a "healthy" urban environment. Researchers X. Jiang *et al*. (2024) proposed an analytical framework for assessing the impact of urban planning on public health, identifying key spatial factors in the spread of infections: building density and morphology, street network configuration, water supply and sewage systems, building ventilation, and functional zoning. The Health Impact Assessment model proposed by the authors demonstrated the possibility of integrating health issues into the early stages of architectural and urban design. A review of pandemics and their spatial consequences was conducted by A.E. Sumanti *et al*. (2023), showing that even in ancient and early medieval times, epidemics stimulated the emergence of specialised types of buildings and urban spaces, including military hospitals, isolated medical complexes, and open spaces for ventilation of the urban environment. The authors emphasised that architecture and urban planning have historically developed as tools for adapting to biological threats, even in the absence of modern scientific understanding of the nature of infections. A. Carbone (2022) traced how repeated outbreaks of plague, cholera, and yellow fever in Buenos Aires in 1867-1871 sparked debates about population control, social inequalities, and the need for spatial reforms in urban planning. These became catalysts for the transformation of engineering infrastructure, regulatory norms, and the spatial organisation of cities, including quarantine zones and the creation of open spaces and green spaces as elements of urban sanitary ventilation. M. Satam (2022) illustrated how the Spanish flu pandemic prompted the development of medical infrastructure in Bombay (now Mumbai). The author examined political decisions and social conflicts in the financing of hospitals and sanitation systems, emphasising that epidemics shaped urban health policy.

In the context of contemporary challenges, M. Amirzadeh *et al*. (2023) developed the concept of urban "pandemic resilience", which encompassed four spatial levels, from housing to the urban and national scales. The researchers emphasised the importance of the living environment, access to green spaces, flexible planning solutions and social inclusion in reducing both the physical and psychological consequences of pandemics. K. Mouratidis & A. Yiannakou (2022) used the cities of Athens and Thessaloniki as examples to show that during the COVID-19 pandemic, better psychophysical health indicators were associated with larger living spaces, lower building density, and access to green areas. X. Zhu & J. Xu (2023) noted that the pandemic has been a catalyst for rethinking the basic priorities of urban planning – from building techniques and density to the role of public spaces and medical infrastructure. R. Florida *et al*. (2020) analysed how the COVID-19 pandemic has affected the spatial concentration of population, jobs, mobility and social interactions. Researchers explained how the pandemic has changed the role of cities as centres of innovation and interaction, requiring the adaptation of spatial models of residential and commercial development to adequately respond to new priorities of safety and pandemic resilience. The study by M. Kang *et al*. (2020) analysed the relationships between built environment characteristics and COVID-19 transmission in megacities. Scientists focused on the role of building density, housing types, and shared engineering systems. The study highlighted the need to rethink architectural standards, particularly ventilation systems and the organisation of shared spaces, in the context of epidemic safety. X. Zhang *et al*. (2022) investigated the effects of crowding and density in urban environments on the spread of COVID-19. The authors analysed data from various urban contexts, demonstrating that cramped living conditions, limited common spaces and enclosed interiors significantly increased the risk of respiratory infection transmission. Based on the results, the researchers proposed urban development and planning measures aimed at reducing space density, developing open areas, and improving the sanitary quality of the living environment. Thus, contemporary research has confirmed that pandemics were factors in the transformation of architecture and urban planning. At the same time, historical experience accumulated from ancient civilisations to modernism has not been sufficiently integrated into contemporary approaches to residential area design. The aim of this article was to identify and systematise architectural and urban planning transformations in cities that have taken place in response to epidemics and pandemics, as well as to trace the transition from empirical and administrative anti-epidemic practices to scientifically based spatial solutions that laid the foundation for contemporary approaches to the formation of the urban living environment.

The research was based on an interdisciplinary approach that combined historical and urban planning analysis, comparative analysis, and elements of spatial interpretation of architectural and urban solutions. The methodological framework was aimed at identifying patterns of the impact of epidemics and pandemics on the transformation of urban residential areas in different historical periods. Urban residential areas were analysed as spatial structures formed in conditions of epidemiological threats and architectural and urban planning principles of residential area organisation, which changed under the influence of epidemics and pandemics. The study used retrospective analysis, which made it possible to trace the evolution of urban planning approaches from ancient and medieval cities to industrial and post-industrial urbanisation. Historical examples were considered not as typological models, but as representative cases that illustrated the general patterns of spatial transformations. Comparative analysis was used to compare historical urban planning responses to epidemics with contemporary approaches shaped by the COVID-19 pandemic. Attention was also paid to analysing the scale of spatial changes, parameters of building density and height, and the configuration of open and green spaces.

Historical epidemics as a catalyst for urban transformation. Sanitary reform and reconstruction of the industrial city

The urban environment has always been closely linked to infectious diseases, and outbreaks of epidemics have been catalysts for profound spatial transformations. C.E. Rosenberg (1992) and F.M. Snowden (2019) noted that it was cities, as forms of high population concentration and social contact, that created conditions for the spread of epidemics, but at the same time became laboratories for spatial responses to these threats. From the 8th century BC, ideas about the connection between public health and the quality of the urban environment began to take shape. Hippocrates' concept of "air, water and place" laid the foundation for the further perception of the city as a factor in the aetiology of disease. M.V. Melosi (1999) and P. Juuti *et al*. (2007) confirmed that in the major centres of the ancient world – Babylon, the cities of the Indus civilisation, Rome – there were already elements of a purposeful organisation of water supply and sewage disposal aimed at minimising sanitary risks. However, in the Middle Ages, much of this knowledge was lost, and European cities developed in the direction of extremely dense construction, due to the requirements of minimising the perimeter of city defensive walls, functional mixing and unsanitary conditions. It was in this context that the bubonic plague of the 14th-17th centuries reached catastrophic proportions, causing not only demographic losses but also radical shifts in spatial thinking (Cipolla, 1992; Alfani & Murphy, 2017).

One of the key spatial responses to epidemics was the practice of quarantine, which developed in the port cities of the Mediterranean and later spread throughout Europe. Quarantine should be seen not only as a medical measure, but as a specific form of spatial management that combined mobility regulation, population segregation, and control over city boundaries. P. Baldwin (2009) analysed quarantine regimes, sanitary borders, systems of movement restriction control, and institutional mechanisms for combating epidemics of cholera, plague, and typhus. The author demonstrated that medical measures always had a spatial dimension and directly influenced the formation of urban boundaries, infrastructure, and regulatory practices – quarantine as a form of spatial management. M. Foucault (1995) analysed the evolution of spatial control practices in society and showed how the concept of "disciplinary space" was widely used to analyse quarantine regimes, sanitary zoning and control of the urban population during epidemics, how space is used as an instrument of behaviour regulation. The architectural embodiment of this logic was quarantine facilities, isolation hospitals and sanitary cordons, which effectively laid the foundations for the further development of infectious disease hospitals and epidemiological zoning systems. As B. Colomina (2019) pointed out, it was epidemics that forced architecture to work with the concepts of invisible threat, sterility, and distance for the first time, which later became fundamental to modernist spatial thinking. In this sense, the quarantine practices of the early modern period (15th-18th centuries) should be seen as predominantly empirical and administrative mechanisms for responding to the epidemic threat, which were not yet based on a scientific understanding of the transmission of infections, but already formed the preconditions for the institutionalisation of spatial control in the city. It was important to note that quarantine measures were never purely technical. They were accompanied by social tension, ethical conflicts, and unequal impact on different population groups. This highlighted the need to consider historical examples not as direct models for replication, but as a source of understand.

The period of early industrialisation in the 19th century was a turning point in the formation of the modern city. As C. Hamlin (1998) noted, rapid population growth, industrial development and mass housing construction during this period led to an exacerbation of sanitary problems and new waves of epidemics, particularly cholera and typhoid. These challenges gave rise to a large-scale sanitation movement that brought together doctors, engineers, architects and city administrators. The author noted that sanitary reforms in Great Britain in the 19th century were closely linked to issues of social justice, housing conditions and urban management and ultimately led to a transition from fragmented, reactive measures to a conscious approach that laid the foundations for modern urban planning and public health. R.J. Evans (2005) conducted a study using the German city of Hamburg as an example, demonstrating how repeated outbreaks of disease stimulated the development of water supply, sewage and regulatory mechanisms for controlling the urban environment. Particular attention was paid to the role of medical knowledge and statistics in shaping causal ideas about the spread of infections. The author showed how epidemics became a catalyst for the transition to scientifically based, systematic urban planning. In other words, unlike periods when there was no modern scientific understanding of the nature of infections, in the 19th century, the fight against epidemics was increasingly based on the results of medical research, statistical observations and the formation of cause-and-effect ideas about the spread of diseases, which led to the transition to systematic urban planning.

The reconstruction of Paris, London, Berlin, and New York in the second half of the 19th century demonstrated how the fight against epidemics became the driving force behind radical changes in the planning structure of cities. D.S. Barnes (2006), tracing the transformations of Paris in the second half of the 19th century under the influence of epidemics and sanitary crises, showed how the fight against "miasmas", pollution, and the spread of infections stimulated the creation of modern city-wide sewerage systems, water purification, and the reconstruction of the street network. The expansion and paving of streets and pavements, and the formation of a network of parks and open spaces had not only infrastructural but also ideological significance – they reinforced the new idea of a "healthy city" as a space of light and air. An article by M. Gandy (2004) provided a critical analysis of the development of engineering infrastructure in North American and European cities in the 19th century through the concept of "urban metabolism". The author showed that water supply, sewerage and sanitation networks became key tools for overcoming epidemics and, at the same time, means of spatial transformation of the city. Particular attention was paid to the relationship between infrastructure, social inequality and power, which allowed to interpret sanitation reforms as an ambiguous process of modernisation. A. Sutcliffe (1981), analysing planned urban development in Europe and the United States during the industrialisation period, showed that street widening, zoning, demolition of dense historic buildings and the creation of green spaces were a response to public health problems. At the same time, the implementation of these sanitary reforms was accompanied by social conflicts, the displacement of poor populations, and increased spatial polarisation of cities. Thus, historical experience has demonstrated the ambivalence of urban planning responses to epidemics, combining progress in health with new forms of spatial inequality. P. Hall (1998), using examples from the evolution of large cities in Europe and North America in the context of cultural, technological and social change, confirmed that epidemics played a significant role in transforming the planning structure of cities, stimulating the development of sewerage, parks, boulevards and water supply systems. The author concluded with the idea of a "healthy city" as the result of a combination of engineering solutions, social reforms and urban planning ideology, which became important for the historical analysis of pandemic transformations.

It is important to note that at the end of the 19th century, as a result of advances in medical science and the emergence of epidemiology as an independent field of knowledge, anti-pandemic measures gradually transformed from practices based primarily on centuries-old empirical experience into a system of consciously formulated architectural and urban planning solutions aimed at reducing the risks of spreading infectious diseases in the urban environment. At the turn of the 19th and 20th centuries, the accumulated experience of sanitary reforms was transformed into a comprehensive architectural and urban planning paradigm, in which health became one of the key design objectives (World Health Organization, n.d.). The spread of tuberculosis and, later, the Spanish flu pandemic contributed to the establishment of the principles of insolation, natural ventilation, functional zoning, and access to green spaces as basic criteria for the quality of the urban environment. In this context, modernism emerged not only as an aesthetic movement, but also as a response to the medical and social challenges of the industrial city. The architecture of residential areas, public buildings, and recreational spaces began to take shape with disease prevention in mind, laying the foundation for the further development of normative urban planning in the 20th century (Verderber, 2003). It was this historical evolution – from empirical sanitary measures to systematic environmental design – that created the methodological basis for analysing contemporary pandemic challenges, particularly COVID-19, which brought to the fore issues of density, floor space, the quality of open spaces and the social sustainability of residential areas.

Transformation of the principles of urban residential area development: COVID-19 as a new type of pandemic challenge for cities

The COVID-19 pandemic was the first global epidemiological crisis to unfold in conditions of mature urbanisation, high informatisation and mobility of the population, and the dominance of megacities as forms of life. Unlike the epidemics of the 19th and early 20th centuries, it unfolded in cities, where basic sanitary and engineering systems already function as a mandatory standard and were not subject to debate (Sharifi & Khavarian-Garmsir, 2020). COVID-19 did not call into question the fundamental principles of sanitary infrastructure, but it did highlight other, less formalised aspects of the urban environment – the spatial organisation of residential areas, the nature of development, the quality of ventilation and the availability of safe recreational spaces. The pandemic has revealed the limitations of the modern compact city model, which is primarily focused on economic efficiency and intensive land use (Florida *et al.*, 2020).

One of the central issues raised by COVID-19 has been the role of urban density in the spread of infections. R. Ewing & S. Hamidi (2015) and C.J. Neiderud (2015) showed that density itself is not a direct factor in increasing epidemic risks; instead, the decisive factor is overcrowding – the overload of the living environment, the lack of open spaces and unequal access to infrastructure. In many cities, the pandemic has shown that residential areas with high building density, increased floor space, minimal inter-building spaces, and insufficient green areas have proven to be less adaptable to lockdowns and mobility restrictions. In such environments, not only did the risks of physical infection increase, but so did the level of psychological stress and social tension (Mouratidis & Yiannakou, 2022). This again returned attention to historical experience, in which the fight against epidemics prompted a reconsideration of acceptable density parameters and spatial separations between buildings. However, unlike the sanitary reforms of the nineteenth century, the contemporary challenge lies not in the radical reconstruction of cities, but in adjusting the principles for forming new residential districts and renovating existing ones. The COVID-19 pandemic has brought to the fore a rethinking of the role of density and height of residential buildings not only as urban planning or economic parameters, but as spatial variables that indirectly influence the intensity and mechanisms of the spread of infectious diseases. Unlike classic engineering and sanitary measures (water supply, sewerage), which have become mandatory and regulated in modern practice, the parameters of building height and area have remained a sphere of design compromises between developer efficiency and the epidemiological sustainability of the residential environment.

In modern interdisciplinary studies, the term "density" has been used not as a universal indicator, but as a set of interrelated spatial characteristics (population density, building density, floor area ratio, residential crowding). S.J. Hejazi *et al.* (2023) and M. Amirzadeh *et al*. (2023) demonstrated that the relationship between density and morbidity is contextual, but densely built-up residential environments are more likely to provide conditions for the rapid formation of local clusters of infection. A study by Y. Chen *et al*. (2022), conducted on several large agglomerations using machine modelling methods, found statistically significant correlations between the morphological characteristics of residential buildings (number of storeys, compactness of buildings, proportion of open spaces) and the prevalence of COVID-19 at the urban district level. Although the authors emphasised the indirect nature of these relationships, the results confirmed that building density can serve as a proxy indicator of a combination of spatial and social risks. Vertical density, i.e. the number of storeys in residential buildings (Fig. 1), has demonstrated specific epidemiological risks in the context of the pandemic.

Contrary to the traditional view that the risk of infection increases only in proportion to population density, a number of studies have shown that the very fact of vertical housing organisation can create additional mechanisms for the spread of the virus. For example, M. Kang *et al.* (2020) found that the infection of residents of apartments in Hong Kong located on different floors (within the same vertical cluster) did not occur as a result of direct contact, but through aerosol transmission mediated by shared sewage and ventilation shafts: the number of infections within a single "vertical column" of flats was statistically significantly higher than in buildings with fewer floors or with a different type of engineering systems. A comprehensive study by S.Z. Chong *et al*. (2025), which combined epidemiological analysis with CFD modelling of air flows, showed that the risk of SARS-CoV-2 transmission between apartments in high-rise buildings can increase by tens of percent compared to low-rise housing types, given unfavourable ventilation configuration and high population density. In particular, in the cases studied, the probability of infection of residents of apartments located more than two floors above the primary source remained statistically significant.

The author P. Zhao (2022) investigated the spatial patterns of infection spread within urban planning and analysed a series of COVID-19 outbreaks in high-rise residential buildings in Hong Kong (Fig. 2). The results showed the existence of so-called vertical transmission clusters, which cannot be explained by either direct social contacts or typical scenarios of household infection. It was found that infected residents lived on different floors of the same building, occupied apartments with the same layout, located one above the other within a single vertical "column" of the building (e.g., apartment type A on the 5th, 12th and 18th floors). At the same time, the epidemiological investigation did not find any direct social contact between them: the residents did not interact with each other, used the lifts at different times and did not occupy common spaces at the same time. The only common spatial and technical factor for these flats was their connection to shared vertical engineering systems, primarily ventilation and sewer shafts. It was these systems that created the conditions for indirect transmission of the virus between floors, allowing the infection to spread without human contact.

Figure 1. Multi-unit residential development with vertical density in Vancouver
Source: Traveling Canuks (n.d.)

Figure 2. Panorama of high-rise residential buildings in Hong Kong
Source: based on K. Zhuk (2021)

An analysis of possible mechanisms of viral transmission in high-rise buildings made it possible to identify several key processes. First, there is aerosol transmission through ventilation ducts, particularly kitchen and bathroom exhausts, where airflows could transport viral aerosols between flats (Wang *et al.*, 2022). Second, an important role was played by transmission through sewerage systems (the faecal aerosol route), the mechanism of which was confirmed during the SARS outbreak of 2003 and later recorded again for SARS-CoV-2 (Kang *et al.*, 2020). Third, a significant factor was the stack effect, in which warm air from lower floors rises upward through microcracks, facilitating the vertical transport of aerosols inside the building. The case examined demonstrated that, under conditions of multi-storey residential development, building height created a specific epidemiological risk linked to the very spatial and engineering organisation of the structure. In this sense, vertical density functions not only as a quantitative indicator of development intensity, but also as a qualitative factor capable of creating hidden pathways of infection spread, invisible within traditional approaches to evaluating the residential environment.

The COVID-19 pandemic revealed the high vulnerability of apartment housing with shared spatial components. A study by W. Luo *et al.* (2022) showed that living in buildings with shared entrances, lift lobbies, and corridors was associated with an increased risk of within-building transmission, even when basic quarantine restrictions were observed. In this context, building height and development intensity act not as direct causes of infection, but as structural factors that shape: the intensity of shared-space use; the frequency of indirect contacts between residents; and dependence on enclosed vertical circulation systems. These findings correspond with the data of D. Duval *et al.* (2022) on the aerosol transmission of SARS-CoV-2 in interiors, which demonstrated that limited air volume, insufficient ventilation, and high user concentration significantly increase epidemiological risks.

Spatial interpretations for architectural and urban planning practice during epidemics

From the standpoint of architectural design of multi-family housing, the results obtained made it possible to interpret building height and density as factors of potential epidemiological vulnerability, which should be considered alongside the social and psychological aspects of the residential environment. It was important to emphasise that this does not imply a rejection of dense development as such, but rather a limitation of its uncritical intensification, especially under conditions dominated by a developer-driven logic of maximising building height and area. The research results reflected contextual relationships rather than universal threshold values, making their direct use as regulatory design parameters impossible. At the same time, they convincingly demonstrated the need to integrate epidemiological knowledge into the process of urban-planning and architectural decision-making, particularly in the segment of multi-storey residential construction, which was likely to be most sensitive to future pandemic challenges.

Building height and residential density have formed not only quantitative indicators of land-use intensity, but also qualitatively new epidemiological risks associated with patterns of spatial interaction and engineering systems within buildings and residential districts. These risks cannot be eliminated solely by technical or organisational measures and require spatial compensation at the level of architectural and urban-planning solutions. One of the least regulated factors in the pandemic resilience of residential districts has been the quality of natural aeration of urban development. At the district scale, this is linked to the orientation of the street network, the width of inter-building spaces, the presence of continuous green corridors, and open public spaces (Samuelsson *et al.*, 2020). Planning configurations of residential development have produced significantly different conditions of natural ventilation. In particular, open or semi-open layouts of residential buildings demonstrated 30-60% higher average airflow speeds in pedestrian zones compared with enclosed perimeter blocks, while the level of air exchange in the inner courtyards of semi-open schemes was 40-50% lower (Fig. 3).

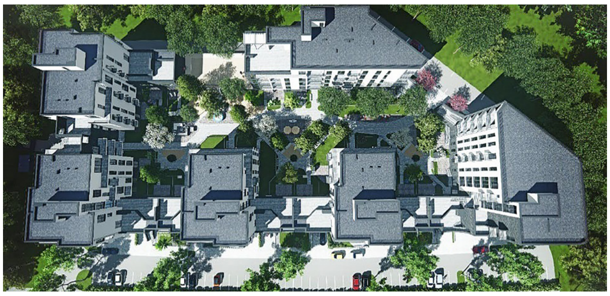

Figure 3. Semi-open placement of residential buildings

Note: the Villa Magnolia quarter, Lviv

Source: photo by I. Gnes

In block development options with through openings or partially open perimeters, the air stagnation zone was reduced by approximately 35-45%, indicating better conditions for the dispersion of aerosol pollutants (Zhang *et al.*, 2022). These effects were complemented by green corridors and open spaces: the presence of continuous green areas was associated with a 20-30% reduction in the time aerosols remain in open spaces, as well as opportunities for safe recreation under quarantine restrictions (Ugolini *et al.*, 2020). An example of a closed residential development scheme was the residential blocks in Barcelona, Spain (Fig. 4).

Figure 4. Enclosed perimeter blocks of Barcelona
Source: Lifestyle 24 (2019)

One particular consequence of the COVID-19 pandemic has been the sharp rise in social isolation, especially among older people, single-person households and socially vulnerable groups. The period of quarantine restrictions revealed the critical role of green and semi-open spaces near homes as a compensatory element of isolation during lockdown. J. Honey-Rosés *et al.* (2021) noted that residents of areas with access to parks, courtyards and boulevards coped better with mobility restrictions, had better psycho-emotional well-being and higher physical activity levels. Thus, the green infrastructure of residential areas emerged not only as a recreational or environmental element, but as an important component of the public health system that needed to be integrated into urban planning decisions at the early stages of design (UN-Habitat, 2021). Quarantine restrictions transformed residential areas from places of transit to the main space of everyday life, which placed new demands on their functional richness (Buffel *et al.*, 2021). The concept of accessibility of basic services within walking distance, which was previously considered mainly from the perspective of convenience and sustainable development, has become a factor of safety and resilience in the context of the pandemic. Local commercial, domestic and recreational functions have reduced the need for travel while maintaining social ties at the neighbourhood level. E. Klinenberg (2018) emphasised that well-developed neighbourhood infrastructure promoted social cohesion among city dwellers and reduced the vulnerability of the population during crises, such as pandemics and heat waves. Scientist formed a theoretical basis for understanding the residential area as a key spatial level, where social interaction and safety can be combined in conditions of limited mobility. The analysis of the impact of the COVID-19 pandemic on residential areas allowed to formulate a number of generalised provisions relevant to contemporary urban planning theory and practice. This was not about revising basic sanitary standards, but about refining the spatial principles of shaping the residential environment, taking into account potential epidemic risks. These principles included: controlled density and height of buildings, ensuring effective natural ventilation, forming a hierarchical system of open and green spaces, and strengthening the role of residential areas as spaces for everyday support and social stability.

CONCLUSIONS

The study confirmed that epidemics and pandemics throughout the history of urbanisation were not random crises, but systemic triggers of architectural and urban transformations. From early forms of water supply and sanitation control in the cities of the ancient world to large-scale reconstructions of industrial cities in the 19^{th} century, threats to public health have consistently influenced the rethinking of density, spatial structure, and functional organisation of the urban environment. Sanitary infrastructure solutions have shaped the basic level of urban safety, but at the same time have been accompanied by social and spatial contradictions. The COVID-19 pandemic has revealed a qualitatively new type of epidemiological challenge, characteristic of conditions of mature urbanisation, global mobility and regulated engineering systems. The pandemic in the 21st century did not call into question basic sanitary standards, but it did highlight issues that had previously remained on the periphery of urban planning discourse. These issues included the number of storeys and density of buildings, spatial congestion, the quality of natural ventilation, and the availability of open and green spaces in residential areas.

It has been determined that epidemiological risks in the residential environment increase with the height and density of buildings. Vertical organisation of space and shared engineering systems can create hidden mechanisms for the spread of infections that are not controlled by the individual behaviour of residents. Recorded cases of contactless infection of residents of vertical clusters in high-rise residential buildings indicate the need for a critical rethinking of the uncontrolled increase in the building height and area in the interests of developers. This practice contradicts the requirements for adapting the residential environment to pandemic challenges. It was also determined that open and semi-open planning configurations of residential buildings demonstrated 30-60% higher natural ventilation rates and 35-45% fewer areas of air stagnation. This confirmed the increased epidemiological risks of excessive densification without spatial compensators. The limitations of the study are related to its focus on the district and city scales, without a detailed analysis of the typology of multi-apartment residential buildings, their internal living spaces and apartments. Prospects for further research lie in supplementing existing regulatory requirements with scientifically based recommendations for architectural and urban planning practices aimed at creating pandemic-resistant housing.

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Вплив епідемій та пандемій на архітектурно-містобудівні трансформації міст

Анотація. Метою дослідження стало виявлення та систематизація архітектурно-містобудівних трансформацій міст, міської інженерної інфраструктури й житлового середовища, що відбувалися у відповідь на епідемії та пандемії. Методологія дослідження базувалася на міждисциплінарному підході, що поєднував історико-ретроспективний, порівняльний і просторово-аналітичний методи із залученням сучасних урбаністичних та епідеміологічних досліджень. Дослідження показало, що від найдавніших систем водопостачання та каналізації у містах Стародавнього Сходу й античності до комплексних санітарних реформ XIX століття та модерністських ідей «здорового міста», архітектурно-планувальні рішення послідовно використовувалися як інструмент протидії поширенню інфекційних захворювань. У статті здійснено історико-аналітичний огляд трансформацій міського простору під впливом епідемій, а також акцентовано увагу на сучасному етапі, пов'язаному з пандемією COVID-19. Показано, що сучасний етап характеризувався зміщенням фокусу з базових санітарно-інженерних рішень на морфологічні параметри житлового середовища, зокрема щільність і поверховість забудови, конфігурацію спільних просторів і ефективність природної аерації. Особливу увагу приділено аналізу просторових параметрів житлової забудови, які опосередковано впливали на епідеміологічні ризики, зокрема поверховості та щільності забудови. На основі сучасних міждисциплінарних емпіричних досліджень було проаналізовано статистично підтверджені кореляції між збільшенням щільності, поверховості житла та більш інтенсивним поширенням інфекції. Підкреслено роль аерозольних шляхів передачі інфекції через спільні інженерні системи багатоповерхових будівель. Узагальнено проектно значущі висновки щодо допустимих рівнів інтенсивності використання простору, а також ролі відкритих і напіввідкритих просторів у зниженні ризиків передачі інфекцій та зменшенні психологічного напруження під час тривалого карантину. Також, акцент зроблено на значенні ефективного природного та механічного провітрювання, організації повітрообміну у спільних зонах (сходові майданчики, коридори, ліфтові холи) та запобіганні утворенню застійних повітряних зон. Практичне значення роботи полягає у формуванні архітектурно-містобудівних рекомендацій, спрямованих на підвищення пандемічної стійкості житлового середовища, в діапазоні «район – багатоквартирний житловий будинок»

Ключові слова: передача вірусної інфекції; житлове середовище; інженерна інфраструктура; поверховість забудови; пандемічна стійкість; архітектура здоров'я