Techniques for Protecting Public Health and Modifying the Urban Environment During a Global Pandemic: Alternative Concepts

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Abstract: The study examines and critically comprehends the vectors of development of science and trends in the emergence of new or transformation of existing approaches to the formation of specialized architectural objects in connection with the pandemic situation based on the analysis of theoretical and design-experimental developments. It has been established that the techniques obtained to protect people's health during a global pandemic will be used in the future when modifying the over densified urban spatial environment as an alternative ecosystem. Trends in the transformation of lifestyles and methods of protecting people through forecasting and preparedness for the formation of special medical facilities in a pre-pandemic situation, as well as methods of social isolation, treatment and service during the pandemic stage of the epidemic have been identified. The formation of autonomous high-rise complexes adapted to the conditions of a post-pandemic situation based on distancing is considered. The principles of modifying the over densified urban spatial environment as an adaptive ecosystem are presented by solving the problem of environmental distribution and use of resources in the urban environment, as well as integrating genetically modified objects and bioactive structures into the urban environment. Attention is drawn to the strategy of preserving people's health and their psychological state in an aggressive urban environment through the use of innovative technologies that contribute to the organization of a healthy lifestyle in the future. The presented selection of design proposals for special medical facilities and methods for organizing urban space in an epidemiological situation allows us to outline directions for searching and conducting further promising research in this area.

1 INTRODUCTION

Throughout their history, the world's largest cities have faced challenges caused by population growth and environmental degradation. Recently, epidemiological threats have been added to their number, which in the context of a global pandemic are considered an extreme situation (Gasanov, Kolotov, Demidenko, Podgornaya, Kadnikova. 2017). One of the effective responses to these challenges is the development and implementation of sustainable mobility strategies, which have gained added value during the pandemic. The tools of architecture and technology to protect health, all other things being equal, made it possible to organize a more sparse urban space and, as a result, reduce the risks of forced mass concentration of people (Saprykina, 2022).

Quite a lot of proposals in theoretical and practical developments are devoted to solving the problem under consideration, which can be divided depending on the stage of the epidemiological disaster (Esaulov, 2020). Some of the work is devoted to forecasting and readiness for the formation of specialized medical facilities in a pre-pandemic situation (Kizilova, 2021). Social isolation, treatment and services during the pandemic phase are considered in project proposals where a more coordinated international response to the outbreak will be required. This forces architects to take a fresh look at the spatial organization of the living environment, as well as at the creation of new specialized objects using innovative engineering solutions (Jasiński,

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2020). The problem of transformation and adaptation of living space to a post-pandemic situation is addressed by project proposals to minimize the negative impacts of the pandemic by forming autonomous high-rise complexes (Ptichnikova, Antyufeev, 2020), as well as pandemic architecture objects based on cluster cities from modular elements (Kochurov, Ivashkina, Fomina, Ermakova, 2020).

It is quite obvious that the methods of protecting people's health during a global pandemic will be used in the future when modifying the over densified urban environment as a spatial ecosystem. In this case, it would advisable to consider solving the problem of environmental distribution and use of resources in the urban environment, methods of integrating genetically modified objects and bioactive structures into urban space, as well as identifying a strategy for preserving people's health and their psychological in an aggressive urban environment in the global danger (Saprykina, 2022).

1.1 Relevance of the issue

Obtaining a new approach to the use of the principles of protecting human health allows us to reveal potential opportunities in the development of methods for modeling, organizing and developing the living environment in an epidemiological situation, and also contributes to the creation of equipped with innovative technologies the specialized architectural objects. Based on these results, it will be possible to carry out their sociocultural design and standardization on the principles of protecting people's stay not only in pandemic situations, but also in a crowded urban environment in terms of developing new technologies for protecting people.

1.2. Problem statement

The purpose of this article is to critically understand the vectors of development of science and trends in the emergence of new or transformation of existing approaches to the formation of specialized medical architectural objects in connection with the pandemic situation based on the analysis of theoretical and design-experimental developments. This will require solving the following specific research problems:

• Identification of trends in lifestyle transformation and ways to protect the population in a global pandemic.

• Determination of techniques for modifying the over densified urban spatial environment as an adaptive ecosystem.

This approach to research necessitates the identification of the most clearly defined direction of scientific activity in architecture and urban planning, its full concentration on the problem of safety in the event of unforeseen disasters, protecting humanity from pandemics, and developing new technologies for protecting people by modifying the over densified urban environment. In this case, it would be appropriate to consider the emerging concepts and trends in the development of the environment living activ of people for solving the problem posed, manifested in the directions that determined the structure of the article.

2 MANUSCRIPT PREPARATION

2.1 Trends in transforming lifestyles and ways to protect people during a global pandemic

2.1.1 Forecasting and readiness to form specialized medical facilities in a pre-pandemic situation

Since ancient times, humanity has coexisted with epidemic-causing viruses that threaten its survival. This situation implies and gives rise to new ways of protecting people and their way of life. On creating a prerequisite for the normalization of a pandemic, in the project "*Self-sustainable skyscraper to combat virus outbreaks*" (authors Yinan Qin, Bo Wei, Jingting Yang, Chao Xie, 2021, China) provides a new way for human survival in a situation where an infectious disease can occur at any time in the future.

The self-sustaining facility, created in case of viral epidemics, is a completely enclosed modular building consisting of three zones. At the bottom of the building is a quarantine area for people infected with the virus. In the middle part there is a virus monitoring zone for diagnosing people's health status, which also serves as a buffer zone for people to travel to work and conduct classes. The upper part of the building is a space for forming a residential area with absolute safety of living.

The high-rise structure of the object connects the three parts of knowledge using a magnetic levitation device, ensuring their functioning and mobility between them in the vertical direction. All human traffic and communications pass through the health monitoring area in the center of the building. This buffer zone allows the facility to be fully controlled

and exist autonomously, which reduces further spread of the virus (Qin, Wei, Yan, Xie, 2021).

Another example is the project "*Epidemic Babel: Healthcare Emergency Skyscraper*" (authors D Lee, Gavin Shen, Weiyuan Xu, Xinhao Yuan, 2020, China). Developed in response to the coronavirus pandemic that originated in in china Wuhan, the emergency medical skyscraper is a rapidly deployable healthcare complex. The project takes into account the fact that an epidemic outbreak usually occurs quickly and there is no time left to respond to it. In these harsh conditions, existing health infrastructure without rapid response can turn an epidemic into a deadly disaster.

The complex has two very important advantages: simplicity of design and quick response. The entire building consists of a steel frame filled with functional volumes and occupies a very small area in the city. The construction scheme is simple enough for any qualified construction team to be able to prepare the site in five days. After installing the supporting structure, the medical team selects the appropriate functional blocks for operation, which will be attached to the steel frame (Lee, Shen, Xu, Yuan, 2020).

This construction scheme allows the complex to respond to a pandemic outbreak in a very short time and help the functioning of existing healthcare infrastructure. All blocks are manufactured in factories and do not require additional time for construction on site. The lightness of the structural frame and blocks also makes it easier to transport to remote locations compared to permanent temporary hospitals.

2.1.2 Social isolation, treatment and services during the pandemic stage of the epidemic

Due to the high infection and death rates of a global pandemic, a more coordinated international response to the outbreak will be required. The need to solve this acute problem is funded reflected in many design and experimental developments.

The project "*Pandemic Emergency Skyscraper*" (authors Ngo Thanh Ha Tien, Dao Dui Tung, 2020, France) proposes a skyscraper for a pandemic emergency as an emergency support system station. The purpose of the station is to withstand a situation like a virus outbreak. Its primary function is emergency medical services to fill insufficient hospital resources through a program with medical equipment of an examination room, intensive care room, treatment room and nursing space.

To meet immediate needs and be assembled in a very short time, the building must use modular technology. Vertically configured buildings contribute to the creation more efficient infrastructure in the metropolitan area where the pandemic outbreak occurs in the first place. This emergency support station is able to adapt to many areas, especially in areas with poor epidemic preparation (Tien, Tung, 2020).

The outbreak of a global pandemic poses a serious challenge to global health, both physically and psychologically. This was discovered by researchers analyzing the medical records of sick patients who were diagnosed with mental health problems in extreme living conditions. Among many such problems, dystonic disorder has a significant prevalence and high relapse rate. This is accompanied by a high burden of diseases caused by various causes, due to associated cognitive and behavioral changes (Bezhan, 2020).

In this regard, the proposed project "*Mood Catcher Skyscraper Design to Treat Mental Disorders during the Pandemic*" (authors Yao Junji, Liu Yuxi, An Peiyan, Chen Yuxuan, Huang Yunting, 2021, China) is a skyscraper for the treatment of mental disorders during pandemic. The high-rise building is designed to meet the needs for general psychological counseling and treatment of common emotional problems. Achieving the results of immersion treatment is carried out through the exchange of information, interaction between the building space and users. The building will also serve as an activity center integrating counseling, therapy, recreation and entertainment. Such experience, according to the authors, can be applied to the creation of resources for the treatment of mental illness in other regions of the world (Junji, Yuxi, Peiyan, Yuxuan, Yunting, 2021).

2.1.3 Formation of autonomous high-rise complexes, adaptable to the conditions of the post-pandemic situation based on distancing

According to experts, in the post-epidemic era, in order to avoid the risk of infection caused by long trips to work and shopping, people's activities will return from the city to the autonomous meet society. Therefore, the project "*Post-Pandemic High-Rise Urban Planning*" (architects Shuxian Li, Qiuchen Zheng, Yujia Hu, Jiaxin Wen, 2021, China) proposes the concept of a multi-story urban education for a post-pandemic situation. In the resulting space of the city between public buildings, essential

supplies (food, energy and anti-epidemic agents) in a skyscraper are installed at the top of the building and transported down to reduce the possibility of infection. In this case, residents spontaneously create their own spaces of activity and living from the bottom up, exercising creative freedom. The space used can be completely isolated from the outside if necessary (Li, Zheng, Hu, Wen, 2021; Li, Zheng, Hu, Wen, 2021).

The widespread use of disposable masks also creates environmental pollution problems. First of all, the raw materials for masks are mainly non-woven fabrics made from high melting index polypropylene materials. This material, firstly, is obtained from oil, which pollutes the air during the production process, and secondly, the waste masks will flow into the sea with rainwater and without burning, threatening the marine ecological balance.

Based on this, the project "*Hyper-Mask Skyscraper*" (authors Yu Liu, Junjie Hou, Jiaxi Shi, Hailin Wu, Ronghui Yang, Jiang An) 2022 (China) proposes, similar to putting a mask on a person, adding a membrane to everything building capable of filtering air to achieve the goal of insulating and filtering indoor and outdoor air. At the same time, in order to improve the internal air circulation, the authors proposed the movement of building blocks in the horizontal direction, which can effectively change the volume of the membrane. This movement can stretch the membrane structure, contract and relax, changing the air pressure in the membrane. When the pressure in the membrane is lower than outside, city air enters the building, which is filtered and cleaned by a lower device. And when the pressure in the membrane is greater than outside, the exhaust air, filled with carbon dioxide and other substances inside the building, flows out of the over him. The exhaust air is cleaned, filtered and released into the urban environment, bypassing the factory premises and the roof garden.

This project was the first time it was decided to use a steel truss in the overall structural system of the building. The design distributes large spatial blocks evenly throughout the entire space and intelligently sets the trajectory of movement so that they can change the volume of the membrane as much as possible. The project uses a generative algorithm to attach structures needed for living spaces to the truss. At the same time, the complex provides for the distribution of public and residential premises with green spaces between blocks. They not only connect different spaces, but also clean and filter the air entering the membrane (Liu, Hou, Shi, Wu, Yang, An, 2022).

2.2 Techniques for modifying an over densified urban spatial environment as an adaptive ecosystem

2.2.1 Solving the problem of environmental distribution and use of resources in the urban environment

Cities play a dominant role in global consumption, production and pollution. In a modern metropolis, extreme living conditions can create complications in the following situations: a high-density urban environment, an inconvenient location in the city and being in the historical zone of the city, as well as the emergence of a pandemic situation. As a result of extensive human activity, conditions for the safe use of urban areas are deteriorating. (Porfiriev, Dmitriev ladimirova, Tsygankova, 2017). Currently, there is an urgent need to develop methods for solving these pressing problems associated with environmental deterioration, resource depletion, erroneous principles of urban planning and development, as well as humanity's entry into a trajectory of unsustainable development (Belash, 2019).

The study of the strategy for sustainable development of society in the context of the problem under consideration requires a rethinking of fundamental social values that contribute to ensuring harmony between man and nature, a more fulfilling life for people, and the preservation of humanity and the biosphere. In this regard, the concept of sustainable development is proposed as one of the most important conditions for the historical progress of society and the implementation of the principle of social justice, based on the principles of human and social security in the context of modern social realities (Ismailov, 2022).

With the continuous expansion of the urban scale and the increase in population in large metropolitan areas, along with pandemic epidemics, "urban diseases" have emerged. In this regard, the concept of "*City Healer Skyscraper*" (authors Wang Changsi, Guo Fang, SiYuan Zhang, 2022, China) is proposed, which focuses on the problem of environmental urban distribution and use of resources. An organic combination of environmental techniques and the living conditions of a city dweller forms a self-sufficient urban ecological system, capable of making full use of clean natural energy for the

implementation of residential, office, commercial and transport activities.

The city skyscraper-healer was initially designed as a single whole, based on the needs of residents, and is divided into two main functional systems - commercial and residential. The mono blocks are designed separately in two systems, but they all follow the same rules: the spatial arrangement of the mono blocks is carried out using a parametric program. When the two systems are stabilized, structural reorganization is carried out at the request of the inhabitants to form a new ecological system. The mono blocks in the two systems are supported by a common large structural column, the interior of which expands into a petal-shaped cantilever structure. To realize the integration of the structure, it holds the mono blocks and is partially connected to the outer shell. To ensure a comfortable life for the inhabitants, the project provides other service spaces, places for social events, as well as for entertainment and recreation (Changsi, Fang , Zhang, 2022).

2.2.2 Integration of genetically modified objects and bioactive structures into urban space

The epidemiological situation requires interdisciplinary research at the intersection of biological, environmental and urban planning sciences. Modern methods of integrating plants with pronounced phytoncidal properties into the open spaces of the city and the interiors of architectural buildings will help optimize the microclimatic parameters of the environment, as well as make it detrimental to microbial communities and more comfortable for human habitation (Popkova, 2020).

To solve a number of important environmental and urban problems in a pandemic, the concept "Living Skyscraper For New York City" is proposed (authors Lesyuk A., Kogut M., Shkolyar S., Ivashchuk E., Duda N., Shkolnik M., Kitsyuk O. , Goncharenko A., 2021, Ukraine) as a "living skyscraper" for the city. According to the authors, the integration of genetically modified trees into the urban space at the stage of their growth and development will restore the balance between high-tech megacities and natural resources, which are gradually depleted.

The skyscraper is designed in the form of a growing tree as a separate living organism with its own root system, watering, and care and development mechanisms, focused on its adaptation to use in architecture. An fast-growing and tall deciduous trees are used, which are planted in groups in specially prepared soil and, as they grow, fill a unique architectural volume. It is assumed that an increase in the circumference of the plant trunk will gradually increase the strength of the wooden structure and improve the self-supporting properties of this system. During the development process, branches of neighboring trees will be grafted at different levels and form a network structure of "hybrid trees" that will form the structure of a "living skyscraper". As it grows, such a skyscraper can connect with neighboring buildings and form green overhanging communications over the block. The functional purpose of skyscrapers may vary depending on the needs of residents and is especially relevant due to the pandemic situation (Lesyuk, Kogut, Shkolyar, Ivashchuk, Duda, Shkolnik, Kitsyuk, Goncharenko, 2021).

This concept is continued the formation of biodiversity of ecosystems in the city to increase the level of comfort of the urban environment during a pandemic. A method is proposed for creating bioactive sustainable structures in the city greening system, designed to improve the environment through the formation of local biocenoses in urban areas (Maltseva, 2020). World food production relies heavily on a very small number of crops and livestock species. Along with changes in land and water use, population growth, urbanization and changing food cultures, lack of crop diversity poses a threat to global food security in the context of a new nutrition paradigm (Saprykina, 2023).

The proposed agro-ecological skyscraper project "New Spring: Agro-ecological Skyscraper" (by Michał Spólnik, Marcin Kitala, 2022, Austria, Poland) is a large-scale structure consisting of proto-garden modules. Each module belongs to a specific biome, containing specific flora, soil, microorganisms, small animals and microclimate. Modules can be freely added, removed or replaced. Hidden behind the shell of the modules and their wooden supporting structure is a core unit filled with hardware functions: seed and plant tissue banks, laboratories, lecture halls, data centers, warehouses and high-tech composts. The capsules are made from cross-laminated wood, allowing for flexibility in manufacturing and a relatively easy, repeatable assembly and disassembly process. Following the principles of agro ecology, each proto-garden is experimental from the very beginning and brings together plants that do not occur in the natural environment. This is especially important in the fight against climate change, where some losses cannot be replaced and new solutions and adaptation techniques are needed. This project, according to the authors,

will stimulate biodiversity and cross-pollination of ecosystems and agricultural crops (Spólnik, Kitala, 2022).

2.2.3 Strategy for preserving people's health and their psychological state in an aggressive urban environment

The development of modern civilization is increasingly moving people away from their natural needs due to the fast pace of life, an unprecedented amount of information, and the complexity of social relationships. In addition, changes in work and rest patterns and environmental pollution contribute to the gradual increase and worsening of mental illness. Sustainable cities should focus not only on saving resources and protecting natural resources, but also on preserving people's health and psychological well-being. In the aggressive environment of a modern city, there is a need to solve the problem of rehabilitative healing of people, it is especially advisable to use innovative technologies in an epidemiological situation.

Thus, the project of a vertical rehabilitation shelter "Helios Rehab Sanctuary" (architect Darren Chan. 2011) proposes the organization of a facility where city residents living under pressure and suffering from the severity of the situation in the city can "escape" on a short time in order to be rehabilitated and, in ultimately return back to society. Residents gather as a community in the rehabilitation tower, where they are treated and supported to live a "clean, peaceful life." The tower is zoned vertically and focuses on healing the BODY (bottom), MIND (middle) and SPIRIT (top).

An external frame based on a "tensegrity" network provides horizontal access to the modules through green ramps. The capsule shells use "hexa-skin" and include integrated TX-Active panels that purify air pollution. They also reflect light onto massive rods, which contain kinetic capsules that capture direct, diffuse and reflected sunlight on photovoltaic surfaces. Depending on climate changes, the capsule opens for cooling, and the rod system provides ventilation, closes for protection, insulation and provides energy savings. After rehabilitation, according to the author, users become rejuvenated and maintain a healthy lifestyle in the future (Chan, 2021).

3 RESULTS AND DISCUSSION

As a result of the study, based on the analysis of theoretical and design-experimental developments, methods for protecting human health in a global pandemic were considered, which will be used in the future when modifying the over densified urban spatial environment as an alternative ecosystem. This made it possible to determine the features of the formation of specialized architectural objects and obtain the results discussed in this review in the following areas considered:

1. Trends in transformation of lifestyles and ways of protecting people during a global pandemic have been identified:

• *Forecasting and readiness to form specialized medical facilities in a pre-pandemic situation* are associated with the development of new methods and technologies for protecting people that affect their lifestyle. Specialized healthcare and medical complexes for these purposes must have a simple design with rapid deployment and response to a pandemic outbreak in a very short time, which ensures absolute safety of living conditions.

.• *Social isolation, treatment and services during the pandemic phase of the epidemic due to the high infection and mortality rates of a global pandemic necessitate a more coordinated international response to the outbreak.* It is proposed to use modularity technology for emergency provision of a medical facility that adapts to meet the needs for general psychological counseling and treatment of common emotional problems.

• *The formation of autonomous high-rise complexes, adaptable to the post-pandemic situation based on distancing,* is associated with reducing the possibility of infection by covering the entire building with a membrane capable of filtering indoor and outdoor air to achieve the goal of isolation. It is planned to include blocks with green spaces in the public and residential areas of the complex for additional air purification.

2. Techniques for modifying an over densified urban spatial environment as an adaptive ecosystem:

• *Solving the problem of environmental distribution and use of resources in the urban environment* is associated with the strategy of sustainable development of society in the context of ensuring harmony between man and nature. A self-sufficient urban ecological system is proposed, capable of making full use of clean natural energy for realization of residential, office, commercial and transport activities.

• *Integration of genetically modified objects and bioactive structures into urban space* will restore the balance between high-tech megacities and natural resources, which are gradually being depleted. A method is proposed for creating bioactive sustainable structures in the city's greening system, as well as the biodiversity of ecosystems and agricultural crops in the context of food security, during a pandemic.

• *The strategy for preserving people's health and their psychological state in an aggressive urban environment* is related to the need to solve the problem of rehabilitative healing of people in the aggressive environment of a modern city due to the increase in their mental disorders, especially during a pandemic. The expediency of using innovative technologies that contribute to the organization of a healthy lifestyle in the future is noted.

The results of the study indicate the identification of a clearly defined direction of scientific activity in architecture and urban planning, its full concentration on the problem of overcoming new epidemiological challenges, on the development of new technologies for protecting humanity by modifying the over densified urban environment.

4 CONCLUSIONS

In the conditions of the modern world and the situation of a global pandemic, the problem of creating new concepts for protective architecture and design of urban space, developing an integrated approach to solving the problem of security in the event of unforeseen disasters arises especially acutely. Obtaining a new approach to using the principles of protecting people's health during a pandemic allows us to reveal potential opportunities in the development of methods for modeling, organizing and developing the living activ environment, as well as creating specialized medical architectural objects in an epidemiological situation.

Based on these research results, it will be possible to carry out sociocultural design and normalization of living active environment on the principles of protecting people's stay not only in pandemic situations, but also in a crowded urban environment in terms of developing new technologies for the safety of residents. Obviously, such a serious problem cannot be solved by efforts in only one practical or conceptual direction. Only an integrated approach that brings together specialists from all areas of architectural and interdisciplinary knowledge can produce tangible results. Therefore, a holistic program for solving security problems at the cultural, economic, political and, architectural level is needed, as well as a new look at the situation for the corresponding development of effective measures.

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