



The Innovative Trends in Architecture and Urban Planning of Health Care Institutions

Irina Bulakh, Margaryta Didichenko, Olena Kozakova

Abstract: The article depicts and systematizes innovative global trends in the field of architecture and urban planning of healthcare institutions taking as the example leading countries in the field of healthcare (Hong Kong, Singapore, and the United Arab Emirates). The territorial, administrative and demographic features that significantly affect the formation and functioning of the architecture and urban planning network of medical institutions are analyzed. The features, indicators, and structure of the public and private sectors of the medical organization of the listed countries are examined in detail. The main innovative trends in the architecture and urban planning of the healthcare network that put the considered countries on the top of the world leaders in the efficiency of healthcare organization rapidly are identified. The trends are considered in urban planning, architecture, medical, economic, environmental, technological and innovative aspects.

Keywords : innovations, trends, design of medical institutions, hospitals, architecture, urban planning.

I. INTRODUCTION

In order to conduct a study by using the systematic approach towards innovative global trends in the field of architecture and urban planning of healthcare institutions, by identifying their current operating features as part of the overall urban development network, it was decided to refer to the rate of the countries all over the globe compiled by the effectiveness of the healthcare system criterion taking into account life expectancy, healthcare costs, dynamics of changes in indicators [1], [2], [3]. According to the international agency Bloomberg data the medicine in Hong Kong, Singapore and the United Arab Emirates has been the leader in terms of quality and effectiveness of healthcare in the world recently [4].

It is worth mentioning that these countries turned to be able to increase their level of medical service in a relatively short period of time, in comparison to the leading European countries [5], [6], [7]. According to it this study is focused on the innovative approaches towards architecture and urban design of medical buildings that make it possible to rapidly and efficiently increase overall efficiency and reduce costs of the functioning and operating of the healthcare sector [8], [9], [10].

II. MATERIALS AND METHODS

The research is mainly composed of a systematic and comprehensive analysis of the medical network and hospital complexes of the leading countries all over the world. An analysis of literature, normative, information sources, graph-analytical methods, photographic fixation, and field examination were used in the study.

III. MAIN MATERIAL

Hong Kong - is a special administrative region of the People's Republic of China located on the Kowloon coast, the territory includes 260 islands and is divided into three parts: Hong Kong, Kowloon and the New Territory [11]. No more than 25% of the total area of Hong Kong (1104 km²) is developed, the rest of the territory is landscaped natural spaces 40% of which belong to preserved areas and reserves [12]. There are two main categories of the medical facilities in Hong Kong: public and private. A feature of the urban organization of the Hong Kong healthcare system is its distribution into 7 clusters, which include 43 public and 11 private hospitals, 49 specialized and 73 general outpatient clinics [13]. The medical clusters formation in the urban health organization system in Hong Kong is the first trend that should be addressed. The term "cluster" is a common term in systemology, economics, computer science and IT, mathematics, astronomy, music, chemistry, physics, biology, epidemiology and generally means a group of identical or similar elements assembled together or close to each other; the homogeneous units unification into the one system. Thus, the entire territory of Hong Kong is divided into 7 autonomous clusters, each of which contains the healthcare organization that involves the interaction of all the constituent elements (primary and secondary level medical care institutions, scientific and educational medical institutions, pharmaceutical and other manufacturers, medical workers and patients) with the goal of effective and high-quality interaction,



Revised Manuscript Received on November 30, 2019.

* Correspondence Author

Irina Bulakh*, PhD of Architecture, Associate Professor, Department of Design architectural environment, Kyiv National University of Construction and Architecture, Kyiv, Ukraine. Email: irabulakh81@gmail.com*, bulakh.iv@knuba.edu.ua

Margaryta Didichenko, MA Architecture, Assistant, Department of Design architectural environment, Kyiv National University of Construction and Architecture, Kyiv, Ukraine. Email: didichenko.margo@gmail.com, didichenko.mo@knuba.edu

Olena Kozakova, PhD of Architecture, Associate Professor, Department of information technologies in architecture, Kyiv National University of Construction and Architecture, Kyiv, Ukraine. Email: olena.kozakova.arch@gmail.com, kozakova.om@knuba.edu.ua

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The Innovative Trends in Architecture and Urban Planning of Health Care Institutions

development and renewal (Fig. A) [14]. Most of Hong Kong's hospitals were built between 1960-90, the oldest one is St. Paul's Hospital built in 1898, and the newest one is North Lantau Hospital constructed in 2013.

Due to the nature of Hong Kong land, a significant part of local hospitals has a compact layout scheme and are high-rise multi-storey centralized buildings.

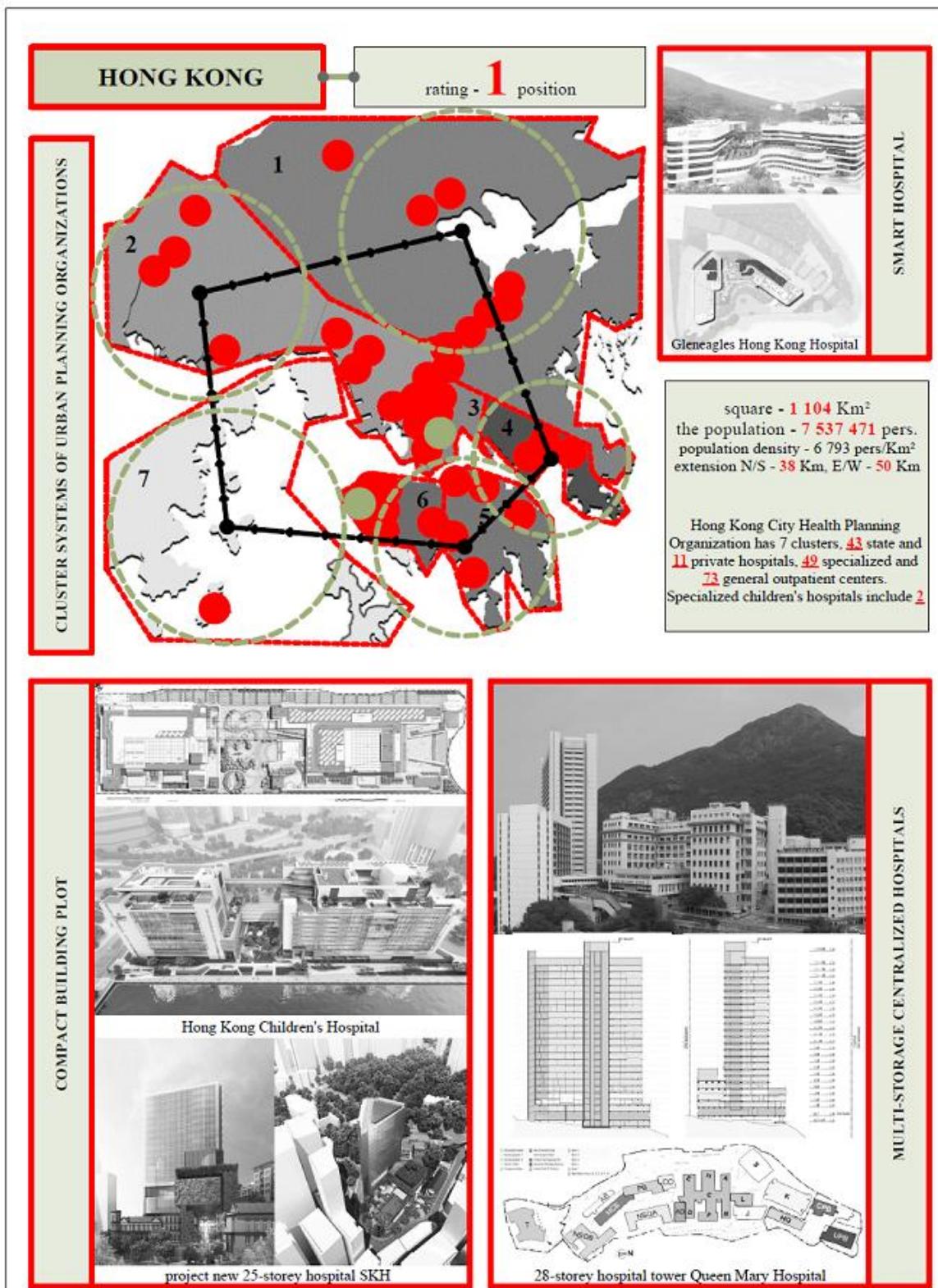


Fig. A. The innovative trends in architecture and urban planning of health care in Hong Kong

One of the main hospitals in Hong Kong is considered to be Queen Mary Hospital, built in 1937, followed by modernization in 1955 and 1983.

The clinical building of the hospital is a 28-story tower and it

is the highest hospital in Asia (137 m).



The hospital has a capacity of 1,400 beds and is the main clinical institutional department of the medical faculty of the University of Hong Kong [15], [16], [17]. One of the features of the Hong Kong healthcare system is the on-time network modernization of the multidisciplinary hospitals with the introduction of advanced digital and other "smart" technologies, which together produce a so-called "smart hospital". Automation of the healthcare sector is one of the most relevant and promising tasks in the world. The latest innovative technologies in the organization of medical processes make it possible to combine a huge amount of data, cloud computing technology, machine learning methods and artificial intelligence solutions. The smart hospital concept aims to create a unified medical information environment, consisting of automation of the main, specialized and auxiliary processes with the ability to exchange data at the municipal, regional and federal levels. Automation of data starts from the moment of applying to the hospital, continuing with automatic health indicators electronic bracelets, operating rooms robotization, etc. Undoubtedly, all these latest technologies impose certain requirements on the architecture and planning organization of medical institutions, in particular, the location of server and monitoring rooms, the size of operating rooms, taking into account robotic equipment, etc.

Singapore is a state-city located on 63 islands in Southeast Asia with an area of 724 km², which is gradually increasing due to the state land reclamation program, which has been operating in the country since the 1960s [18]. The population of Singapore is 6 million people. Primary care is provided by general practitioners of public and private institutions: in Singapore, there are 18 state polyclinics and about 1.5 thousand private medical institutions. Primary medical care, preventive medical services, health education services, outpatient treatment, aftercare after discharge from the hospital, immunization, diagnostic and pharmaceutical services are provided in state polyclinics. It should be noted that state clinics satisfy only 20% of the total demand for medical services, the rest 80% is covered by commercial practitioners and medical centers [19], [20]. The Singapore hospital sector has its own specifics: public health facilities are divided into 2 groups: the National Health Care Group (NHG) and the Singapore Health Service (SingHealth). This distribution was carried out with the aim of vertical integration of services, expanding the interaction of these groups, stimulating innovation and improving the quality of medical care. NHG and SingHealth established hospitals and special centers as private companies that are totally owned by the government. The urban planning network of healthcare institutions in Singapore is represented by 5 state general hospitals, 1 state psychiatric hospital; 1 state children's and women's hospital; 13 commercial hospitals with full state participation; 9 private hospitals; 6 national centers for the treatment of cancer, eye, skin, heart, dentistry and neuropathology. The capacity of the 85% of state hospitals and specialized centers varies from 185 to 2010 beds, private hospitals - from 20 to 345 (Fig. B) [21], [22].

The average duration of patients stay in public hospitals was 5.8 days with the average occupancy rate of about 85%.

The global success of Singaporean healthcare was declared in 2000, thanks to a government program of the development of biology, biotechnology and medicine. In 2004, a unique scientific center "Biopolis" was created - a medical and scientific town, which has 9 buildings with a total area of 220 thousand m² and more than 4 thousand scientists, adjacent to the territory are the State University, Polytechnic Institute, National University Hospital and the Ministry of Education [23]. Thus, Singapore is an example of the innovative development of biomedicine, creating an ecological incubator of medical technologies.

Another development trend of medical institutions which is a trademark of Singapore and other countries with the state-of-the-art healthcare systems is the research, development and integration of cutting-edge medical equipment and technologies. From this position, the world first Integrated Operations Center based on the use of digital technologies was launched in Singapore, equipped with the intraoperative magnetic resonance imaging and high-precision radiosurgery with advanced visual equipment.

A further architectural feature of Singapore's healthcare facilities is the use of advanced environmental design principles. A vivid example of the environmental and energy-efficient design of hospitals is the Ng Teng Fong (NTFGH) and Jurong (JCH) hospitals, built in Singapore in 2015 by the architectural office CPG Corporation. These state hospitals are focused on comprehensive patient care by combining emergency and outpatient care with a multidisciplinary hospital. It should be noted that the territory of the hospital complex is literally compact due to its location in a compacted urban environment, but the active use of landscape and landscaping creates an oasis in the middle of the "urban jungle". An ecological design approach by using the cutting-edge engineering technology that allows Ng Teng Fong and Jurong hospitals to use 38% less energy than a regular Singapore hospital and 69% less than the average hospital in the United States. Using solar panels on the facades of hospitals allows us to accumulate electrical energy, provide lighting, heat recovery, the operation of heat pumps and heat exchangers to maintain the required temperatures in buildings. An air conditioning control system monitors the current energy use of the system, solar thermal collectors provide 100% of the hot water needs, and a filtration system processes the wastewater for reuse. In addition, rainwater collection, LED lighting, daylight and room usage sensors, monitoring of the building management system, occupancy levels and sleep modes are used to save and rationalize energy consumption. Energy efficiency is also influenced by the unique aerodynamic shape of hospital buildings, which in combination with the funnel-shaped profile of the floors contributes to the natural movement of fresh air inside the buildings. The provision of natural ventilation for 70% of the area of the Ng Teng Fong and Jurong hospital buildings was achieved by taking into account the climatic features of the area, the use of breeze airflows which are typical for the monsoon seasons in Singapore [24], [25].



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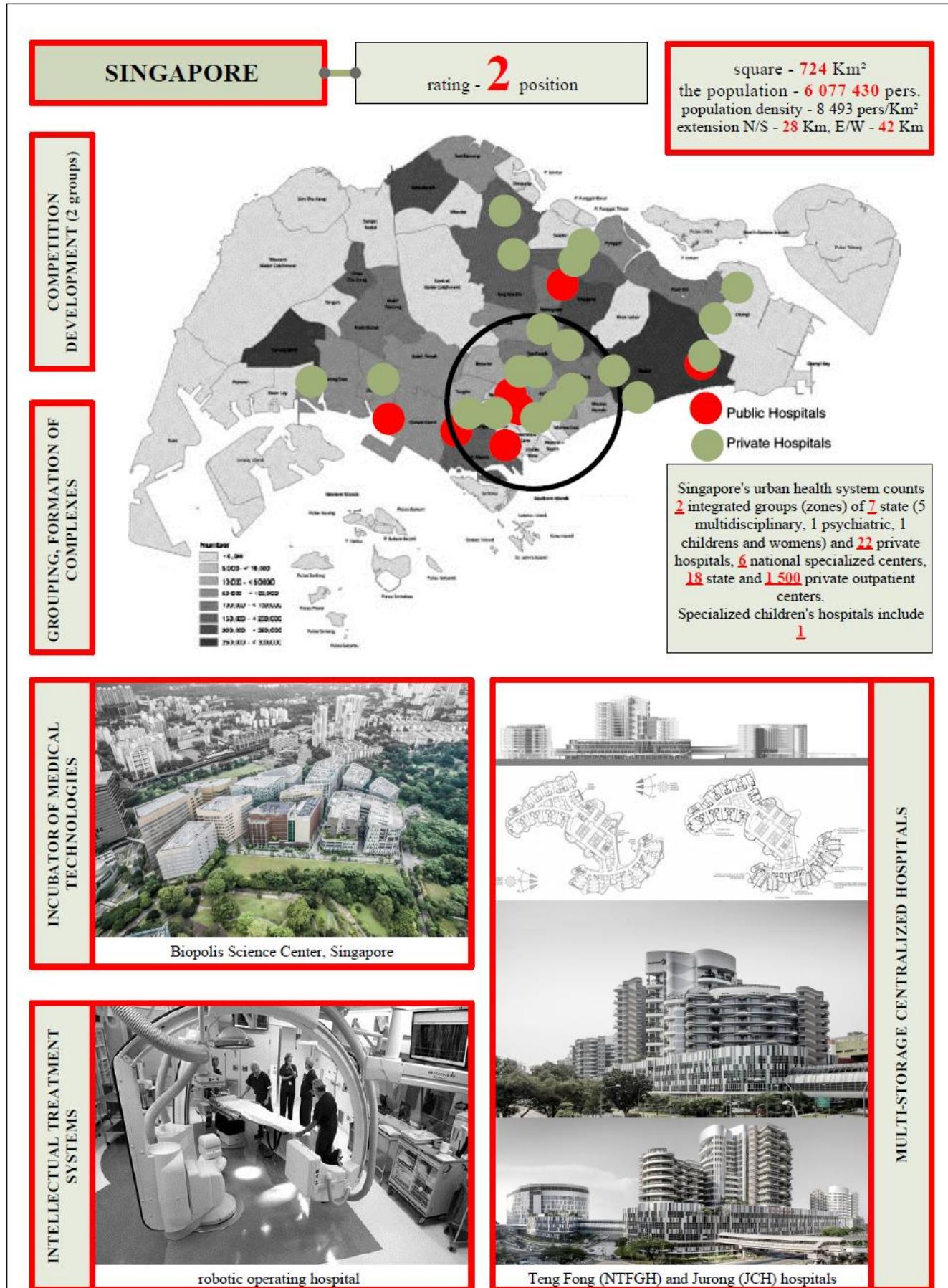
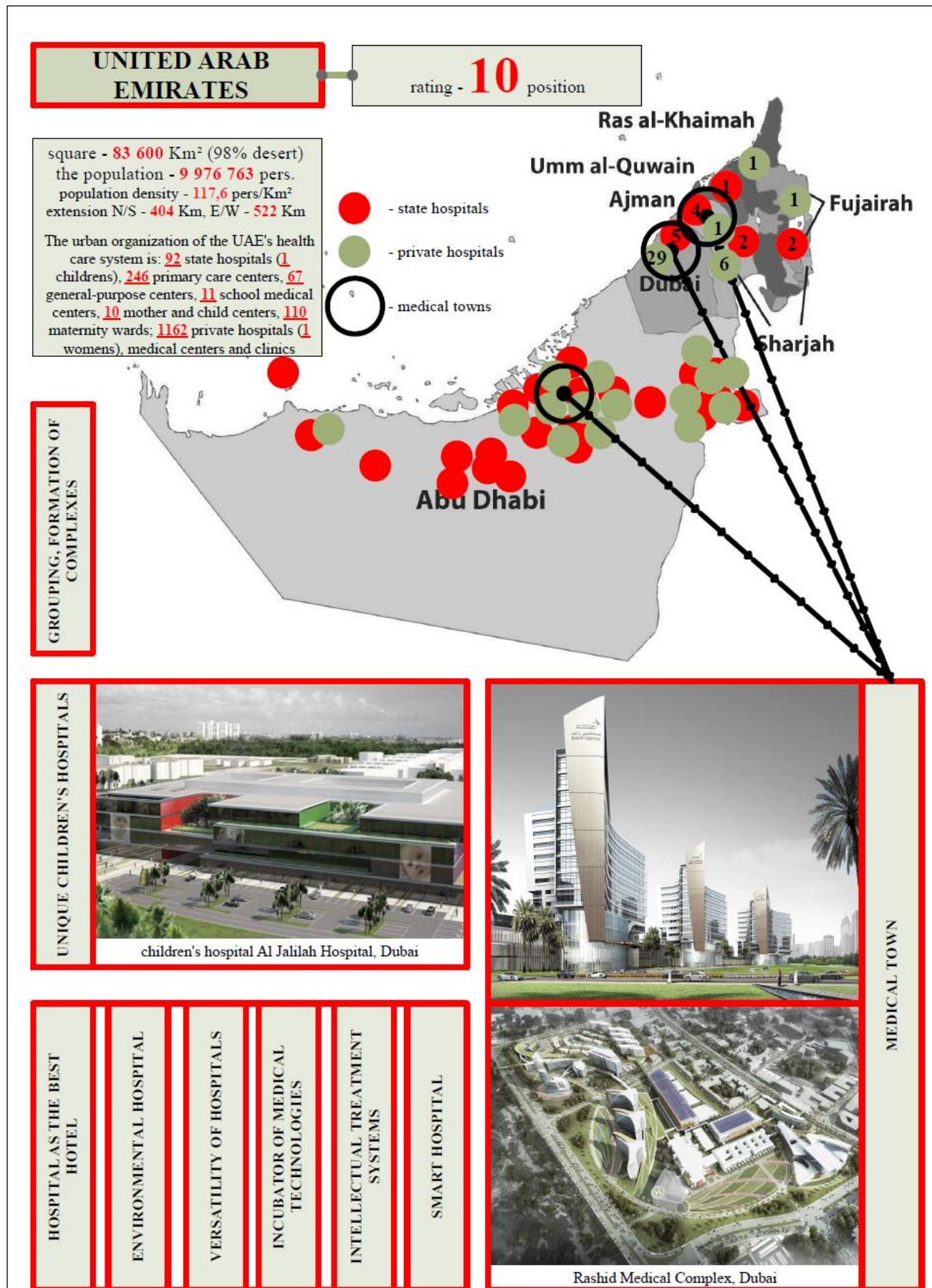


Fig. B. The innovative trends in architecture and urban planning of health care in Singapore

**Fig. C. The innovative trends in architecture and urban planning of health care in United Arab Emirates**

The Innovative Trends in Architecture and Urban Planning of Health Care Institutions

The United Arab Emirates is a federal state in the Middle East consists of 7 emirates, each of which is a separate state with an absolute monarchy. The total territory of the state is 36 83,600 km², while most of the UAE (98%) is occupied by the largest desert in the world. The population of the UAE is about 10 million, 70% of which are male workers from South and Southeast Asia [26]. The first and for a long time the only hospital in the UAE was built in 1960. Today, the country has 92 state hospitals, 246 primary medical care centers, 67 general medical centers, 11 school medical centers, 10 mother and child centers, 110 specialized maternity wards, as well as 1162 private hospitals, medical centers and clinics (Fig. C) [27], [28]. It should be noted that in 2014, the first and only specialized women's hospital Brightpoint Royal Women's Hospital (of particular importance for a Muslim country) was built in Abu Dhabi, and in 2016, the Al Jalilah Hospital in Dubai [29], [30].

The peculiarity of the UAE urban-planning organization of the healthcare system is the maximum enlargement of medical institutions, the formation of comfortable medical complexes with the provision of primary, multidisciplinary secondary and specialized care in one place without distribution due to the age category of patients. The enlargement and comprehensiveness of UAE medical institutions in recent years has transformed into a tendency to create medical towns such as Sheikh Khalifa Medical City, Dubai Healthcare City, Sharjah Healthcare City. Thanks to the active development of the UAE healthcare sector, its concentration in the largest cities of the country, the high level of quality and innovation, favorable conditions have developed for the spread of "medical tourism". Hospitals and medical centers in the UAE are designed and built not only for the actual population of the emirate but also for a significant percentage of wealthy patients from other states. Among such large-scale medical projects that are currently at the design and construction stage is the Rashid Medical Complex in Dubai, which is supposed to become the first seven-star hospital.

The Rashid Medical Complex project is an urban-planning medical complex, divided into several functional zones. In the northern part of the medical complex, it is planned to build a clinical unit with a hospital for 900 beds, a recovery center, a central laboratory, a conference room, an educational and research center, and parking for 4000 slots. On the south side, it is planned to arrange rehabilitation, commercial and university blocks, which include a rehabilitation hospital for 320 beds, a rehabilitation center and sports medicine, a hotel for 250 rooms, a family hotel, shops, six apartment buildings for hospital workers, villas for medical consultants, a parking for 2400 slots. Since the UAE government recognized the design of environmentally friendly cities as the leading urban planning principle, the architects' main task was to solve the issues of how to harmoniously integrate the medical complex into the environment by adding green roofs, collecting and using rainfall, solar panels, geothermal systems, double-glazed windows with thermal energy resistance. The introduction of innovative technologies, the smart hospital system, is becoming the basis and priority for the development of the healthcare system at the UAE government level [31].

In the UAE hospitals there is a transition to a fully robotic system for conducting surgical interventions, which allows you to create the most sterile conditions in the operating rooms, minimize damage to the human body and, as a result, reduce the patient's hospital stay and rehabilitation period. Also, the opening of the world's first Emirates Space Hospital in Dubai was recently announced. The hospital will focus on the implementation of the UAE Centennial 2071 program and the National Space Program. The medical institution will be an example of how telemedicine can be used in the future - not only in Earth hospitals but also in space ones by testing mobile units of the hospital is planned on Mars. Treatment at Emirates Space Hospital will be carried out using nanorobots, which are able to independently find diseased cells in the body and treat them [32], [33].

IV. RESULTS

The study is aimed to identify innovative trends in the architecture and urban design of healthcare facilities in the world's leading healthcare countries taking Hong Kong, Singapore and the United Arab Emirates as references. The main identified trends should include rational, effective and economical approaches to the architecture and urban planning of medical buildings, complexes and the entire urban healthcare system, which are based on urban, architectural, medical, economic, environmental, technological and innovative aspects ultimately. The main and unifying trend should be called a qualitative rather than quantitative approach to the architecture and urban medical network design.

V. CONCLUSION

The analysis of innovative trends in architecture and urban planning of medical institutions of the leading countries in terms of its efficiency and quality of healthcare (Hong Kong, Singapore, the United Arab Emirates) made it possible to extract the following groups of trends: urban planning (cluster system of urban planning organization; compact site development; developed primary health care network as part of family practice, medical complexes and medical cities), architecture (typological diversity of primary medical institutions services, lack of standard design; enlargement and height of medical facilities; "hotel" architecture of hospitals), medical (family medicine; multidisciplinary; uniqueness of children's specialization), economic (distribution of private medicine; competition, as an incentive for development), environmental (ecological design approach and energy efficiency), technologically innovative (smart hospital; intellectual treatment; medical technology incubator).

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AUTHORS PROFILE



Irina Bulakh PhD of Architecture, Doctoral studies, ORCID 0000-0002-3264-2505, Web of Science ResearcherID: Y-2572-2019. *Education*: Master of Architecture, Department of Design architectural environment, Kyiv National University of Construction and Architecture, Kyiv, Ukraine. *Place of work*: Associate Professor, Department of Design architectural environment, Kyiv National University of Construction and Architecture, Kyiv, Ukraine. *Publications*: 84 publications, of which 75 scientific papers (27 in scientific publications of Ukraine, 23 publications in scientific publications of other countries, 1 publication in a scientific foreign publication included in the WEB OF SCIENCE scientific base, 11 publications in periodicals of Ukraine, 9 abstracts for conferences, 1 author's journal of scientific articles and 3 collective monographs), 9 works of educational-methodical publications. PhD dissertation "Principles of symbolizing the architectural and artistic image of the urban environment" (2016), Doctoral dissertation "Dynamics of the city planning development of the system children treatment complexes". *Field of research*: architecture, urban planning, theory of architecture, aesthetics of architecture, artistic image in architecture, design of medical buildings and hospitals. Membership: Member of the Union of Architects of Ukraine, member of the scientific committee of scientific journals (Ukrainian International scientific journal "Internauka", Polish International scientific journal "Colloquium-journal", Polish Multidisciplinary scientific edition "World Science"), Polish Conference Organizing Committee "Science, Research, Development".



Margaryta Didichenko Master of Architecture, PhD candidate. ORCID 0000-0002-4306-8596. *Education*: Master of Architecture, Department of Design architectural environment, Kyiv National University of Construction and Architecture, Kyiv, Ukraine. *Place of work*: Assistant, Department of Design architectural environment, Kyiv National University of Construction and Architecture, Kyiv, Ukraine. *Publications*: 13 scientific papers, including 6 publications in scientific periodicals of Ukraine, 1 publications in scientific periodicals of other countries, 6 abstracts for conferences. *Field of research*: theory of architecture, architecture, urban planning, urban morphology, historical areas development.



Olena Kozakova PhD of Architecture, ORCID 0000-0003-0593-266X. *Education*: Master of Architecture, Department of Architecture, Kyiv National Academy of Fine Arts and Architecture, Kyiv, Ukraine. *Place of work*: Associate Professor, Department of information technologies in architecture, Kyiv National University of Construction and Architecture, Kyiv, Ukraine. *Publications*: 11 publications all in scientific papers (8 in scientific publications of Ukraine, 3 publications in scientific publications of other countries, 7 abstracts for conferences. PhD dissertation "The formation and development of traditions of Western Ukrainian hotel's architecture of XVII – XIX centuries" (2016), Field of research: architecture, urban planning, theory and history of architecture, design of hotel buildings.

