The Role of Small Medical Units in a Smart City – The Case of Timisoara

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Abstract
Objectives: The present paper intends to analyze the challenges for medical services in this century from a Smart City perspective. Prior work: Smart City concepts have primarily addressed technical and infrastructural functions (e.g., urban transportation, energy, water supplies, etc.) and have less targeted medical institutions. However, any modern urban structure requires competent, technologically updated, and synchronized medical services for diverse communities. Approach: We start from the main differences between large and small medical units (e.g., urbanistic structure, specific services, networks, technological equipment) to analyze the position of small units within medical networks and the role of public agents in the optimal configuration of this system of services. We use the case of small clinics to study medical units from an inter-relational perspective by applying the concept of Grid to the offer of medical services. Results: In contrast to large medical institutions in a Smart City, small medical units show more flexibility by not requiring a long-term urbanistic restructuring of public services. While not covering the wide range of functions provided by large units, small clinics offer specialized services and provide patient monitoring and long-term medical assistance, contributing greatly to patients' quality of life. Communication networks between units ensure patients' transition from large to small medical units. A Grid model can be applied to the present network to optimize medical functions by implementing new data collection systems. Implications: Inter-professional networks (e.g., between medical units, public beneficiaries, technological providers, and scientific researchers) are key to Smart City medical services. Accessing technological innovations (e.g., long-distance monitoring of physiological parameters, machine-learning systems, pattern recognition algorithms) will be a priority for small units. Value: The role of small medical clinics in a Smart City is analyzed within a Grid and linked to future challenges and technological advances.

Keywords: Grid, urbanistic flexibility, long-term medical assistance, quality of life, technological equipment.

1. Introduction
The concept of a Smart City is gradually becoming more popular in the modern world. An estimation by the UN stated that by 2050, approx. 70% of the world's population will live in cities [1]. Moreover, the latest COVID-19 pandemic has had a major impact on the general quality of life: the fact that the majority of infections occurred in urban areas [2] signaled the daily risks to residents' health and the need to improve living conditions, but also health monitoring, diagnostic and intervention methodologies.

In a Smart City, a sustainable digitalized infrastructure becomes key to offering its inhabitants better living and healthcare conditions. The Grid concept is used to represent complex interrelations between energy requirements and distribution, information communication and security, and sustainable pricing policies [3]. On the one hand, from the institutional perspective, a “smart grid” should contain integrated systems that allow data interoperability between healthcare systems, public safety, housing, social and emergency services, and transportation. On the other hand, from the public perspective, the functionality of a smart grid is ensured by several factors, such as health literacy, technological education for system navigation, access to information, and knowledge of rights and responsibilities [2].

While extensive research on Smart City topics focused on technical & infrastructural functions [2], [4], [5],[6], [7], there is an emergent interest in developing and studying smart solutions for healthcare system implementations [8], [9], [10]. Such solutions rely on affordable and effective technological innovations and inter-professional networks between researchers, healthcare providers (medical units), technological providers, and public beneficiaries. Several Smart Cities already exist in the world (e.g., Cascais in Portugal, Louisville in Kentucky, USA, and Kashiwanoha in Japan). In Romania, the first Smart Medical City – Enayati Medical City –was completed in 2021. The facility offers a wide range of medical services for patients of all ages, as well as collaborations with other medical units, research activity, and public dissemination of results.

A systematic review of the literature on healthcare applications in smart cities rendered several targeted domains, such as population surveillance, promoting and supporting healthy lifestyles and active aging, organizing care services, emergency administration, and socialization [10]. The revised articles suggested technological applications for disease and accident surveillance and prevention, monitoring and improvement of environmental conditions and food quality, as well as promoting emotional and physical well-being. The proposed innovations included gamification endeavors, interactive platforms, tracking sensor implementations, personalized recommendations of exercises, and emergency management applications.

Other researchers have reviewed the implication of AI [11] and the Internet of Things (IoT) in Smart City healthcare systems [9], highlighting the importance of interoperability between medical units (i.e., reliance on blockchain technology, wireless sensor networks, and machine learning technology to access and exchange patient data between units and specialists). Implementing such technology is designed for diagnosis, health monitoring and prognosis, treatment of acute and chronic conditions, long-term outpatient care, and as an aid for complex decision systems in emergencies [9].

The introduction of technological advances lays a Smart City’s foundation and contributes to the healthcare system (e.g., mobile sensors that offer remote measurements of bodily functions and ambient sensors to detect changes in the environment and keep optimal parameters) [8]. We start from the assumption that accessing technological innovations (e.g., long-distance monitoring of physiological parameters, machine-learning systems, pattern recognition algorithms) is mandatory for any medical unit in a Smart City. Reliance on a grid constitutes a prerogative for effective functioning in a Smart City. However, several challenges ensue from accessing novel technology, such as data privacy and security [12], accessibility and usability, and interconnectivity with other smart services [8], [13].

Apart from the challenges related to the inter-relational dynamics between various healthcare providers, special attention should also be paid to remote patient monitoring systems. We note the entry into the public health arena of new players, unencumbered by the rigors of the traditional medical establishment (e.g., telephone services, internet providers, providers of computer programs intended for remote monitoring of biological parameters), encouraged by the need for specialized data processing services. This picture also includes providers of patient management services and administrative follow-up programs. The power with which the new services and functions press on the medical functional ensemble forces the prefiguration of some general operation principles (e.g., Cyber Security, safety, private Life, protection of data, and interference of the state in individual life) that address both the current system and potential new systems. Therefore, a Smart City is not only an effort toward the optimal provision of quality public services but also a challenge that goes to the root of philosophical questions.

Most studies on the topic targeted complex medical facilities, so there is a lack of research concerning small healthcare facilities in a Smart City. Therefore, our objective is to highlight the role of small clinics in the service networks offered to citizens as well as the role of the rapidly evolving technological innovations in prefiguring the optimal functioning of this service system.

We will investigate medical units from an inter-relational perspective and apply the Grid concept to the offer of medical services. We will compare large medical units (regional hospitals, county hospitals, municipal hospitals) with smaller medical units (dispensaries, associations of medical offices, polyclinics, private clinics) from the perspective of their infrastructure, specific functions, interrelations, and technological equipment.

2. Small Clinics in Timișoara – A case study

An online search of the current situation of small clinics in Timișoara identified 235 private and public medical units in contractual relation with CAS Timiș. These include individual practices, small clinics with restricted specializations, and units operating under the license of larger medical systems (e.g., Medlife, Medicis, Hyperdia). Faced with a continuously evolving technology, these units need to re-organize as the medical system advances and new technological opportunities become available.

Our objective is to answer the question of whether to allow this situation's natural development or filter it through theoretical principles of desirability (e.g., liberalism vs. coordinated development, data security and privacy, interference of the state in private affairs, etc.). In other words, should small clinics become engulfed by a continuously evolving city? Or can a Grid model be applied to sustain their partially autonomous functioning and ensure service interconnectivity in a Smart City?

To answer these questions, we analyze the role of small clinics in a Smart City from the perspective of infrastructural flexibility, specialization of medical services, inter-relations with other healthcare providers, and technical utilities.

2.1. Infrastructure

Large medical facilities and hospitals are complex systems that must function autonomously within an urban structure that, in turn, must make room to accommodate them. The hospital of the future is an autonomous mini city that includes its own medical buildings that serve patients and relatives (e.g., restaurants, cafeterias, chapels), administrative buildings, buildings that provide electricity, water, heating, medical equipment, intervention services, internal and external transport services, road systems, parking lots, rescue access areas, helicopter landing pads, etc. Large medical facilities force accessibility issues to be addressed. The hospital is an important node in the urban transportation system, the electricity or water supply system, etc.

In Timisoara, the main hospital is the County hospital (Timiş County Emergency Clinical Hospital-SCJUT). SCJUT assures all the emergency hospital services for Timis county and the region. Nevertheless, this hospital was erected in 1974 (totaling 1030 beds and 13 specialty clinics) and has been continuously functioning for almost half a century. Apart from the main building, a few new buildings were added in the last decades. Despite being the newest large hospital in Timisoara, it is far from complying with modern functional requirements (not enough parking place, no recreational or green areas, no circuits for families, no cafeteria, etc.)

Building a new large hospital to meet actual requirements is a huge endeavor. However, a new hospital must conform to the necessities of the future (50-100 years from now). Society's high developmental rhythm makes it difficult to predict the future needs of large medical units. Moreover, we expect a permanent delay or unconformity of large units with the needs of a continuously changing society. The example of the City Emergency Hospital in Timisoara shows how difficult it is to think, build and operationalize a large medical unit. The construction started before 2000 and stopped for two decades; now, it is being reconceptualized in a modern way. The estimated costs are 200-400 million euros [14]. On the other hand, small medical units seem more adaptable and flexible to changes.

While there is no single definition of standards required for large smart hospitals [15], there are several proposed urbanistic requirements [16]. The urbanistic infrastructure of the hospital of the future in a Smart City will comprise man-made facilities built on the inter-communication between various systems (e.g., energy, water supply, transportation, disaster-risk management, healthcare, information communication systems). Any hospital in a Smart City should comply with the United Nations' Sustainable Development Goals and be built within a Smart City platform. Such a platform contains three interfaces: the data acquisition interface relying on sensing and infrastructure providers, the interoperability interface relying on data and computation providers, and the services interface relying on services and application providers [16]. Based on this framework, smart hospitals should be built in a Smart City which resides and operates on the following infrastructures: energy, water supply, transportation, communication, disaster-risk prevention, cultural and sports, educational, social welfare, and healthcare infrastructures, which should all be managed through IoT and AI technologies [16].

With such extensive requirements, the “hospital of the future” could be an intangible objective for medium sizes cities like Timișoara (which totaled 306,615 inhabitants in 2022) or even for the entire Romanian social reality. Looking back to the last decade of the Communist era, constructing the House of Parliament took 17 years (a period that witnessed the fall of the Communist regime) and reached costs of about 4 billion euros. It also imposed significant urbanistic sacrifices on Romania’s capital city, despite currently using only 30% of its capacity [17]. Such a project is just a small part of what a hospital of the future would represent.

Constructing the “hospital of the future” is a complex and difficult process that implies, among other aspects, populating the hospital with human resources of different specializations and competencies. Brain hunting (i.e., searching for qualified workforce – a mandatory requirement for a large hospital) is a time-consuming process that can be boosted by extremely attractive wage and salary policies. These, in return, can cause financial imbalances in the system (e.g., higher costs supported by the state and the community, inflation of costs expected to be absorbed in many years of functioning, or an influx of employees with insufficient training).

Moreover, the hospital of the future comprises various public health services in a single location that could be vulnerable to war, calamity, terrorist attacks, power breakdowns, etc. Such exposure to various adverse factors could contribute to the system’s collapse. By contrast, considering a grid of small and medium-sized medical units as an alternative to large medical cities could offer other advantages, from easier management to better inter-collaboration for solving patients’ problems.

Small medical facilities are much more flexible from an urbanistic standpoint. They do not necessarily impose a large-scale and long-term urban vision. They also do not require rethinking the entire public service system, for instance, a special helipad or parking lots for thousands of cars. On the other hand, facilitating specialized training for the existing employees of small and medium-sized medical units could provide a more cost-effective alternative to brain hunting.

2.2. Functions

While large public institutions offer services in all medical specialties, small medical units are more specialized in certain medical services. Large units generally manage health problems in critical situations by offering emergency and intensive care services. They do not take over the follow-up activity and long-term surveillance healthcare procedures. Rather, patients’ quality of life depends greatly on the long-term supervision and dispensarization procedures that are taken over by small medical units.

Small medical units usually have specific functions, specialized in sub-domains to satisfy the needs of various patient categories. For instance, the first MRI equipment in Timișoara was acquired in 1999 by Neuromed, a system of clinics specialized in medical imagistic services. Since then, other units have emerged, and the network of clinics has spread across the city. Figure 1 displays a segment of medical units selected by just one searching criterion ("medical units Timișoara").

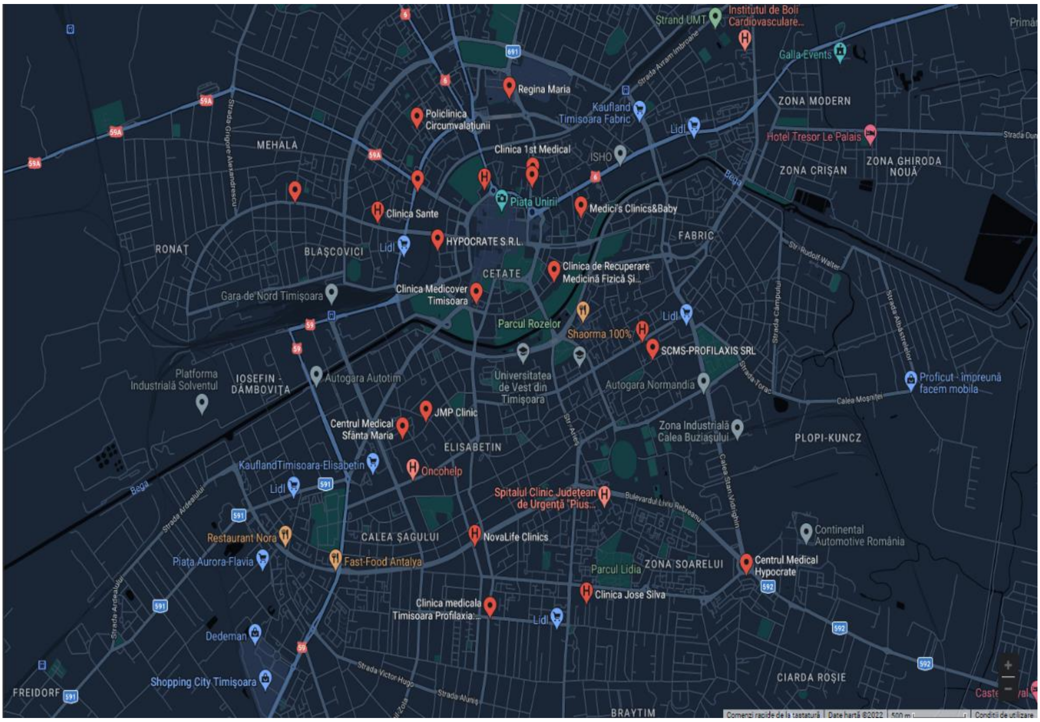

Fig. 1. An image of medical units dispersed in Timișoara
Source: Google Maps (28.11.2022)

2.3. Grid of interrelations

Looking at the current map of large and small medical facilities, we notice that they are dispersed throughout the urban structure. They partly work autonomously, but there are also predefined interrelations. For example, the imaging center or laboratory provides imaging or laboratory services to all other medical facilities, and the family doctor redirects patients for specialist consultations in other medical units. However, without the appropriate technology to facilitate data management, the collaboration between specialists is often hindered by spatial or technological constraints. As it is currently presented, a Grid model can be applied to this network for its optimization. Data collection and intervention systems are needed to optimize the medical service grid's functionality.

Rapid technological development also requires the increasing specialization of medical centers to accommodate and operate new technologies. Technological management is currently attributed to specialized units or laboratories rather than large medical institutions. For instance, controlled clinical trials on multiple sclerosis are carried out in specialized centers following strict protocols specialized for this disorder). By comparison, in a Smart City, patient tracking and monitoring technology will have to be managed by units specialized in collecting, storing, and processing data and all units involved in case management. Therefore, the inter-relations between units are key to better assistance of patients. In this regard, medical services are no longer localized but become “cross-border” in a Grid concept where specialists in different areas can collaborate on a patient’s case.

2.4. Technology

Before the COVID-19 era, the concept of telemedicine seemed distant. A version of remote medicine was practiced based on local sensors (e.g., an EKG performed by the family doctor, with the data collected and remotely interpreted by a specialist). The pandemic forced the appearance of telemedicine which involved other practical challenges, from the quality of the medical services to the weight that objective information has in the diagnostic process. In the COVID-19 era, collecting anamnestic information and performing remote clinical examinations became a priority among diagnostic modalities and overtook other objective data collection modalities (e.g., physical, imagistic, or biological assessment).

The remote tracking systems of patients and citizens represent an even more complicated issue. Currently, technology allows us to track the location, heart rate, electroencephalography, the patient's movements, the number of steps taken, the duration and quality of sleep, and many other parameters of interest. Such data will grow and will require more powerful analysis systems. New science will arise solely from tracking these medical sensors, collecting, organizing, and transmitting the data. Complex machine learning and pattern recognition systems will allow the anticipation of several medical events (e.g., the onset of atrial fibrillation and a possible stroke), as well as new intervention protocols corresponding to new nosological entities that will be identified through these systems. For instance, advances in robotics could soon facilitate remote operation procedures carried out by robots who either assist or completely replace human surgeons or help patients in their daily functioning.

Machine learning technologies connected with sensors that collect information directly from patients could lead to the early diagnosis of neurodegenerative diseases (e.g., Alzheimer’s dementia, Parkinson’s disease). Therefore, the analysis of complex physiological, biological, verbal, para-verbal, and motor information collected from the patients and their environments could facilitate the recognition of crisis or emergency situations and the corresponding intervention methods. To this end, effective inter-relations between the individual medical units that assist patients and systems of collecting and transmitting patient-related information are essential [8], [13]. For instance, in Europe, a smart intervention system in emergencies relying on drones will be implemented in the Netherlands. In a traffic accident, the information is picked up by environmental and physical sensors and transmitted to nearby drones with various functions (e.g., intervention, blood analysis, etc.).

Healthcare monitoring and intervention technologies are reaching new performances in a rapidly evolving technological world. System interoperability within a grid seems key to their effective functioning. Nevertheless, several questions need to be answered within the current perspective: Who owns the electronic data collected from patients, and who has the right to transfer them: the patient? The technology provider? The data processing medical unit?

3. Conclusions

Small medical units are part of the medical system and are essential for supplying medical services. They cooperate with large and medium medical facilities to answer the specific or general needs of the patients. Optimal healthcare implies good functioning and an effective interplay of the „actors" involved in the process. This Grid interplay needs communication tools and flexibility to adapt to new challenges.

Nowadays, we note a fascination toward large medical units and ambition to build such mega hospitals. Still, we consider those just a segment of a medical system that must cooperate and compete for better services.

New technology, the nearby war, and the COVID-19 pandemic unraveled the fragilities of the accepted truth. New complex dynamics with many operants could be favored and envisaged. The technologies providers who are not restrained by the „Hippocratic oath" act following their economic interests in a free market. Some ethical limitations of health care providers are not applicable, and they develop fast, offering surprising solutions for medical use. Consequently, combining a free market for medical services and a centralized public healthcare system seems a convenient solution for the desired outcome.

The functioning of the medical Grid depends on data traffic and communication. Large amounts of data require continuous data management and quests to access information. We do not know yet who the data owner is: the patient, the technology provider, or the medical unit. Nevertheless, the transparency of patients' medical data raises issues related to their right to privacy and intimacy. Questions like "How transparent should the data be?" still need to be answered.

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