

HEALTHTECH IN ENSURING THE RESILIENCE OF COMMUNITIES IN THE POST-PANDEMIC PERIOD

Olena Pakhnenko,  ORCID: <https://orcid.org/0000-0002-4703-4078>

Ph.D., Sumy State University, Ukraine

Tomasz Pudło,  ORCID: <https://orcid.org/0000-0002-9931-3271>

Department of Production Management, Faculty of Mechanical Engineering and Mechatronics, West Pomeranian University of Technology in Szczecin

Corresponding author: Olena Pakhnenko, o.pakhnenko@biem.sumdu.edu.ua

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Abstract: *The COVID-19 pandemic has led to increased adoption of digital technologies in healthcare. According to most researchers, this contributed to increasing the resilience of medical institutions, healthcare systems and communities to the pandemic challenges. The dynamic development of HealthTech continues in the post-pandemic period. The article purpose is to summarise the current directions of HealthTech development, analyse main patterns of the global and Ukrainian digital health market development and study possibilities of HealthTech use to increase the resilience of communities and healthcare systems to natural and man-made emergencies. The article systematises the types of HealthTech by components, types of technology and stages of application. It was determined that all basic digital technologies such as the Internet of Things, artificial intelligence, BigData, AR/VR, 3D modelling and others are used in modern healthcare systems. Specific areas of applying digital technologies in healthcare are telemedicine, wearable devices recording health data, specialised mobile software, etc. The analysis of the global digital health market development allowed us to identify the largest volumes and growth dynamics of the digital health market in the European and North American regions. By type of technology, the largest share of investment is directed to mHealth and telemedicine. By components, the digital health market development is almost equal. The article defines the forecast volume of the global and European digital health market for 2024. It examines development of the Ukrainian Electronic Healthcare System, which registers electronic medical records of created and performed medical referrals, examinations, procedures, diagnostic reports, treatment plans, medical conditions, electronic prescriptions, vaccination records, medical conclusions on temporary disability and birth. Dynamics decrease in electronic medical records from March 2022 due to full-scale war invasion was revealed. Digital health technologies contribute to raising efficiency and effectiveness of healthcare systems by reducing costs; increasing availability of medical services, flexibility and adaptability of these systems. Achieving these benefits should be accompanied by ensuring the protection of patients' personal data and clearly regulating levels of access to this data, as well as minimizing digital gaps and maximizing the coverage of the population with HealthTech services.*

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Introduction. The COVID-19 pandemic has significantly changed the face of modern medical systems. Efforts to adapt to the pandemic challenges and rebuild healthcare systems in accordance with new social needs and living conditions have led to rapid changes in healthcare branch itself. One of the key transformation directions has become deeper healthcare digitalization. In particular, that concerns dynamic development of telemedicine, wearable devices and diagnostic tools, electronic systems of medical prescriptions, etc. In this case, completely new approaches were not created, but there was a rapid implementation of existing developments, which often became the only option for obtaining medical advice or diagnosis during the pandemic. As researchers note, in 10 months, the pandemic did what would have taken 10 years to evolve.

Having significantly accelerated during the pandemic, digital technologies found a positive response from patients, doctors and medical institutions. In the post-pandemic period, the growing dynamics of the digital health market continues with investments in HealthTech. However, despite the advantages of digital healthcare, the rapid adaptation of technological solutions also had certain disadvantages, such as insufficient regulation and protection of patient data (The Economist Intelligence Unit, 2022). In this regard, relevance of these issues has risen in the post-pandemic period. Therefore, analysis of the HealthTech impact on communities should be comprehensive and take into account not only the created benefits, but also the potential risks.

Therefore, the article purpose is to systematise modern directions of HealthTech development, analyse main patterns of the global and Ukrainian digital health market, research possibilities of the HealthTech use to increase resilience of communities and healthcare systems.

Literature review. The issues of society digitalization and digital technology use are quite popular in current research. Chandra et al. (2022) explored major digital technologies such as 3D printing, artificial intelligence, autonomous robots, biosensors, telemedicine services, the Internet of Things, virtual reality, holography, etc. for their potential applications. The authors identified healthcare as one of the main areas (along with online education and Work from Home (WFH) environment) with the most promising and effective applications.

Issues of resilience in relation to the digital technology use arose long before the COVID-19 challenges. In a 2016 publication on the results of a large-scale technology program for providing digital services to the public to promote health and well-being in the UK, Devlin et al. (2016) noted that resilience, adaptability and flexibility are key facilitators of transition to digital health models.

Academic interest in studying HealthTech has increased significantly during the COVID-19 pandemic. Some of these studies include examining the HealthTech advantages and disadvantages, their role in ensuring the sustainability of healthcare supply chains, the resilience of medical institutions and the positive HealthTech effects on communities. In particular, Nouhi et al. (2022) analysed current and future long-term consequences of the COVID-19 pandemic on healthcare systems. Based on this analysis, use of digital health platforms was identified as one of the possible options for increasing healthcare resilience in future.

El-Sherif et al. (2022) focused on the study of two major digital technologies in healthcare: telemedicine and artificial intelligence. The authors agreed with the WHO conclusions that artificial intelligence was an important component to overcome the COVID-19 crisis. However, they also draw attention to the concerns that arise in connection with artificial intelligence use, such as privacy, transparency and security.

Tilahun et al. (2021) after analysing use of basic digital technologies, such as telehealth, mobile health, Internet of Things, artificial intelligence, big data, etc. during the COVID-19 pandemic, developed proposals for more effective use of digital tools in healthcare.

Sindhu (2022) determined that digital technologies in the post-COVID period can contribute to safer and more efficient delivery of healthcare services while their adaptation requires an appropriate ecosystem. According to the author, adoption of digital medical services is influenced by the patients' trust, which in turn depends on the quality and availability of services. The main factors that form a favourable ecosystem for the healthcare digitalization are resilience of the hospital staff, medical service capacity, technological and regulatory support.

Beaulieu and Bentahar (2021) focused on the healthcare supply performance. Having determined that supply chains in healthcare are not as productive as in other industries, the authors proposed to overcome the existing shortcomings using digital technologies. Furstenu et al. (2022) also considered the feasibility of using digital technologies to increase the resilience of healthcare supply chains. Among the main digital technologies that can be used to achieve these goals, the researchers identified big data analytics, predictive health data analysis and remote monitoring of inventories.

Mbunge et al. (2021) treated various types of digital technologies such as artificial intelligence, drones, nanotechnology, sensors, blockchain robotics, Internet of Things, cloud computing, etc. as a basis for

Healthcare 5.0. At the same time, the authors noted that resilience of digital healthcare systems depends on effectiveness of overcoming organisational, technological and infrastructural barriers.

Paton et al. (2022) conducted a review of open source digital health projects and proved that they provide greater access, equity and resilience to healthcare in high- and low-income settings.

Rubbio et al. (2020) investigated the concept of resilience in healthcare systems from an operation management perspective and evaluated the role of digital technologies in promoting and enhancing resilience capabilities.

Tortorella et al. (2021) investigated resilience of hospitals in terms of four abilities of resilient systems: to monitor, to anticipate, to respond, to learn. The authors justified that digital technologies can contribute to all four of these abilities through remote consultations and real-time care planning; digital non-invasive care; interconnected emergency medical care; digital platforms for sharing patient data and information.

Many researchers considered the healthcare digitalization in relation to climate change and the environmental component. On the one hand, climate change creates new risks for public health and must be taken into account in the development of smart cities policy. In this aspect, digital technologies can contribute to sustainability and resilience of communities, including healthcare (Lapao et al., 2023). On the other hand, introduction of a digital healthcare model allows reducing the environment burden, thus positively influencing the ecological component (Lokmic-Tomkins et al., 2023a).

Methodology and research methods. In the study, methods of logical generalization, analysis and synthesis were used to systematise the HealthTech types as well as to establish the digital health impact on resilience of communities during the COVID-19 pandemic and in the post-pandemic period. Trend analysis methods were used to forecast the size of the global and European digital health market using linear and exponential trends. In addition, the article uses methods of comparative and statistical analysis to study the structure and dynamics of HealthTech development in the world and to analyse performance indicators of the Ukrainian Electronic Healthcare System. The study statistical base was formed on the basis of open official data of the National Health Service of Ukraine as well as data from the Global Market Insight reports on the digital health market development. The main study hypothesis is that use of modern digital technologies in healthcare can increase resilience of medical institutions, communities and the healthcare system in general to various emergency situations.

Results. Today, HealthTech is a rather extensive and diverse direction. Firstly, that is explained by the diversity of modern digital technologies and their high development level. Secondly, it comprises the healthcare system complexity. Thirdly, it deals with different possibilities and application ways of digital technologies.

Technologically, all basic digital technologies find their use in healthcare. Such technologies include artificial intelligence, the Internet of Things, blockchain, 3D printing, BigData analytics, etc. We consider these technologies to be basic because they are used in many spheres of activity. On their basis, specific technological solutions inherent in certain types of activity are formed. For example, Internet of Things technology forms the basis for use of wearable healthcare trackers and monitors. 3D printing is used for realistic reproduction of bones and whole organs. It helps in training interns and doctors, performing complex surgical operations and engaging trial treatment. Augmented Reality (AR) & Virtual Reality (VR) are also effectively used in training doctors and treating diseases.

The entire set of technologies used in healthcare can be organised into groups depending on components, technology types and application stages (Figure 1). By components, HealthTech is divided into hardware (physical products), software (centralised storage of patient information) and services (healthcare services provided by digital technologies).

Healthcare use of basic technologies has manifested itself in the formation of technological solutions and technological developments: wearable devices, remote monitoring of patients, telemedicine, electronic health records and e-prescribing systems.

In addition, the entire set of technologies can be divided by the stage of HealthTech implementation: technologies mediating supply chains, technologies used for patient diagnosis, treatment or follow-up.

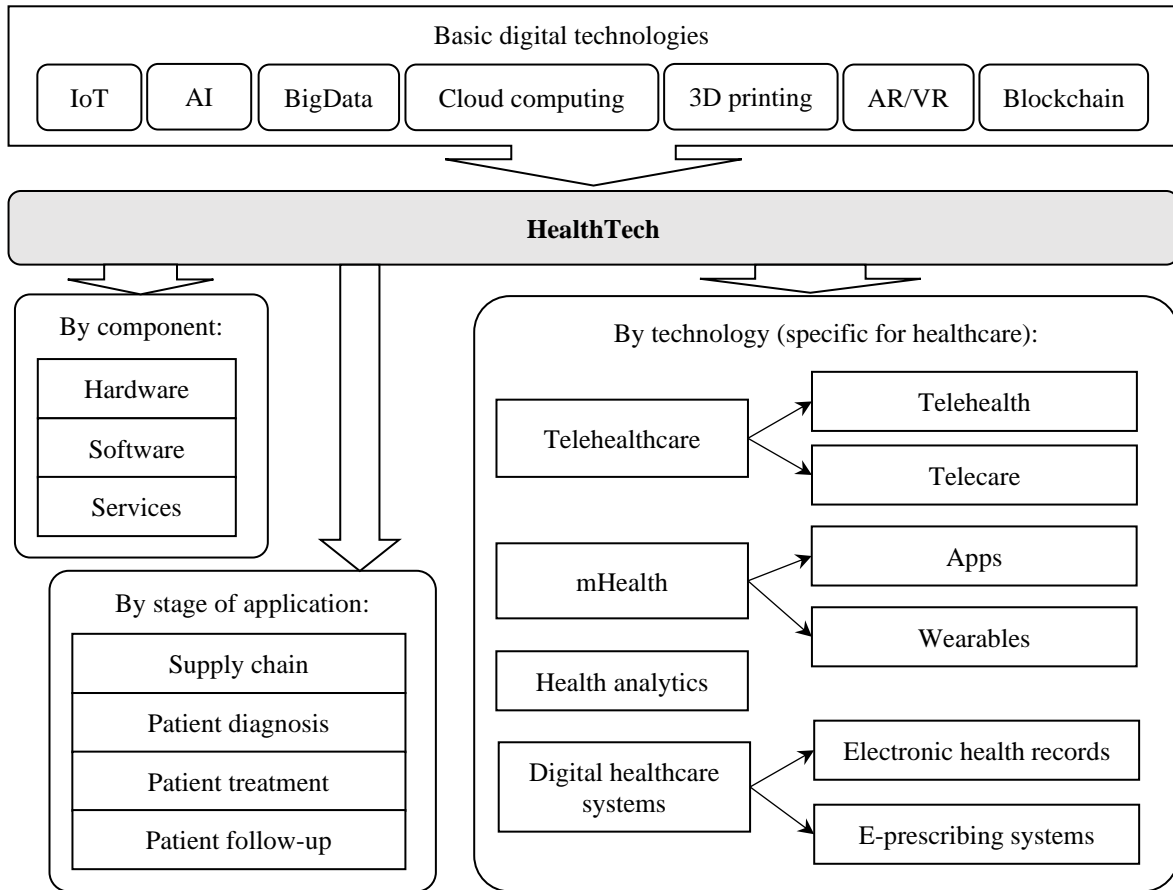


Figure 1. The HealthTech typology

Sources: developed by the author based on (Global Market Insights, 2023; Lokmic-Tomkins et al., 2023b; Tortorella et al., 2022).

The modern HealthTech market is growing annually, investments in various components of HealthTech are increasing. According to Global Market Insights (2023), leaders of this market by region are countries of the European and North American regions. As of 2022, the global HealthTech market for each was USD 233.6 billion. 45% (104.9 billion dollars) of that is the volume of the North American HealthTech market; nearly 35% (80.5 billion dollars) are indicators of the European market (Figure 2).

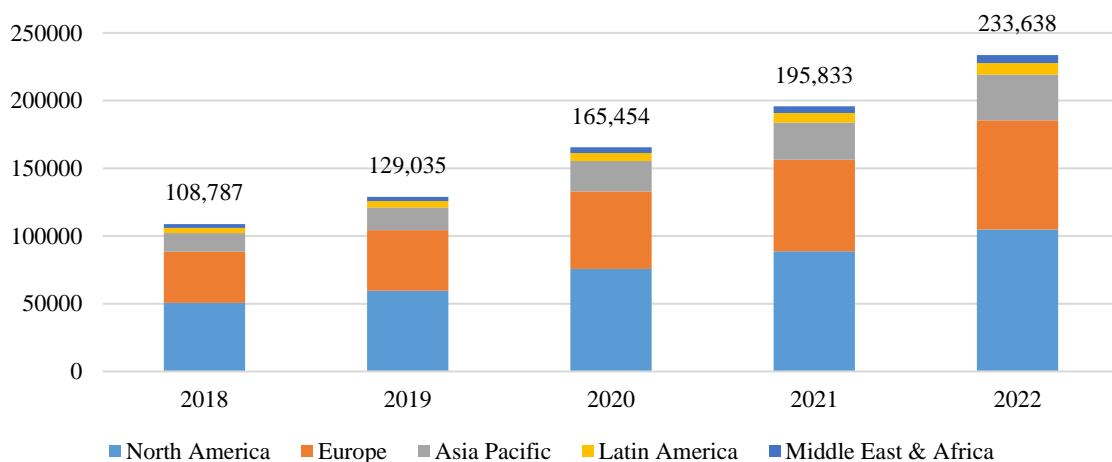


Figure 2. The dynamics and regional development of Digital Health Market, USD Million
Sources: developed by the author based on (Global Market Insights, 2023).

By type of technology, mHealth and telemedicine are currently the most invested. Each of these

components accounted for about a third of the market in 2022. By components, the distribution of investments in HealthTech is approximately equal (Figure 3).

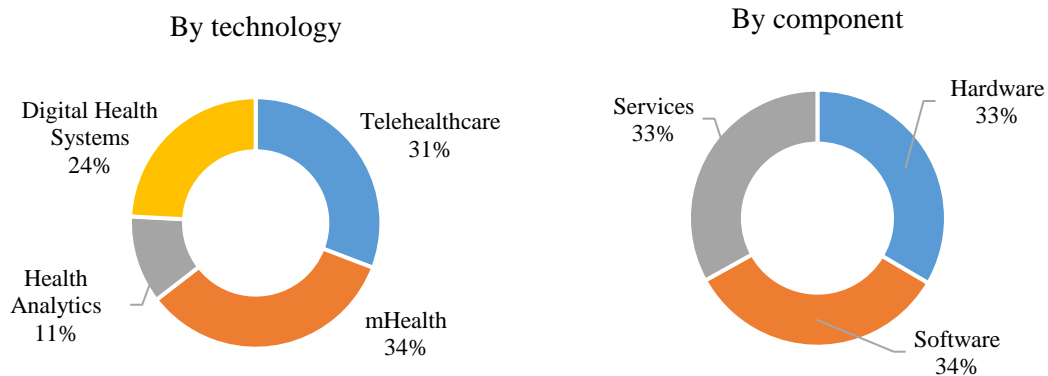


Figure 3. The structure of digital health market

Sources: developed by the author based on (Global Market Insights, 2023).

It should be noted that available sources of data on the digital health development provide slightly different estimates of the size of global and regional markets. This is due to complexity of the market structure and different methodology of taking into account various components and types of technologies. At the same time, all studies agree that the digital health market will continue to grow in future. According to various forecasts, the global HealthTech market will reach 600-1000 billion dollars in 2030.

Currently, the digital health market is growing annually in a linear trend. Given that the usage of fitness and health mobile applications is increasing, as well as the popularity of mHealth, the HealthTech market can be expected to grow exponentially in the coming periods. Based on the construction of forecasts using two types of trends (linear and exponential), it is found that in 2024 the global HealthTech market will reach the size of 284 billion dollars with linear growth and almost 400 billion dollars with exponential growth (Figure 4). Given the limitation of actual periods to seven years, forecasts for a longer period are not statistically reliable.

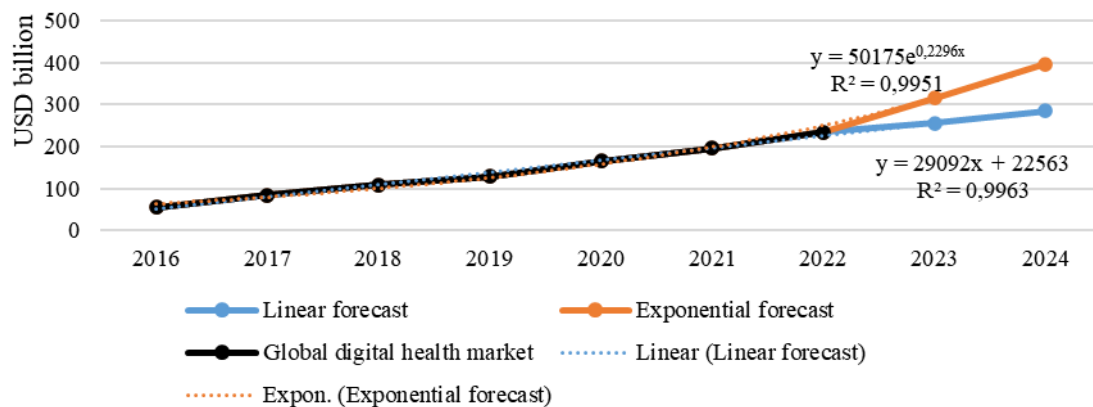


Figure 4. Global digital health market forecast size

Sources: developed by the author.

A similar study of the forecast size of the digital health market based on trend analysis was carried out for one of the largest regional markets, namely Europe. The forecast results showed that by 2024, the European digital health market can be expected to reach 100-140 billion dollars, according to linear and exponential trends, respectively (Figure 5).

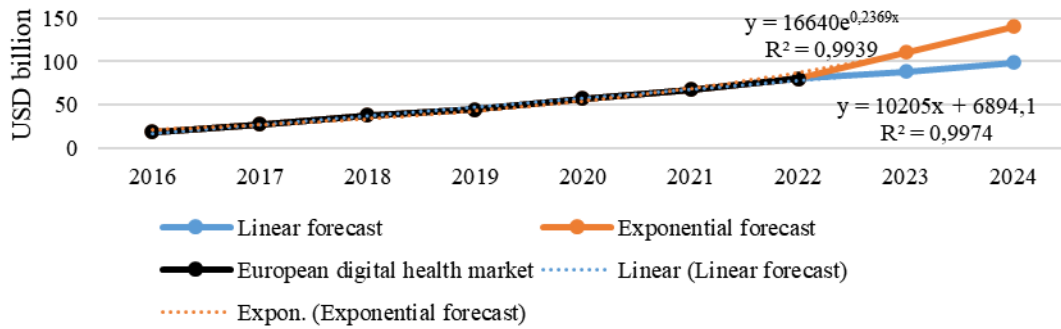


Figure 5. European digital health market forecast size

Sources: developed by the author.

The obtained results of the forecast size of the global and European digital health markets are statistically valid. The R-squared value above 99% for all forecasts shows that the obtained equations quite accurately describe the existing trend towards the change in the size of the digital health market.

One of the key areas of the HealthTech development is Digital Health Systems. They provide collection, storage, processing of medical records; creation of electronic prescriptions and medical referrals; management of other medical information in electronic form. An example of a Digital Health System is the Electronic Healthcare System (EHCS) in Ukraine. This system is based on a hybrid model. This means the union of two components, functioning of which is provided by the state and businesses, respectively. In this system, the state owns a central database in which all key information is stored. In addition, the state establishes the EHCS rules and standards, which guarantees the safety of the system. The second component is a collection of medical information systems from various commercial organizations that provide services to users. At the moment, more than 30 medical information systems with different functionality are connected to the central database, among them: Helsi, iClinic, Health 24, Tabletki, nHealth and others.

This architecture of the electronic healthcare system provides, on the one hand, sufficient reliability and stability, and on the other hand, a competitive choice of electronic services for users and system flexibility. Saving data in a single central database creates advantages for patients (the possibility of changing doctors or medical institutions without losing access to medical history), wide management opportunities for medical institutions and state regulatory bodies, as well as opportunities for scientific research based on depersonalised data on all provided medical services.

The Electronic Healthcare System of Ukraine contains electronic medical records regarding created and completed medical referrals, examinations, procedures, diagnostic reports, treatment plans, medical conditions, created electronic prescriptions, vaccination records, medical reports on temporary incapacity and birth.

The first records in the EHCS appeared in 2019 and during the 1st and 2nd quarters of 2019. They related exclusively to the creation of electronic prescriptions. In subsequent periods, electronic records became more diverse, and the total number of electronic medical records began to grow extremely dynamically. As of the end of the 1st quarter of 2023, the central database contains more than 1.7 billion medical records (Figure 6).

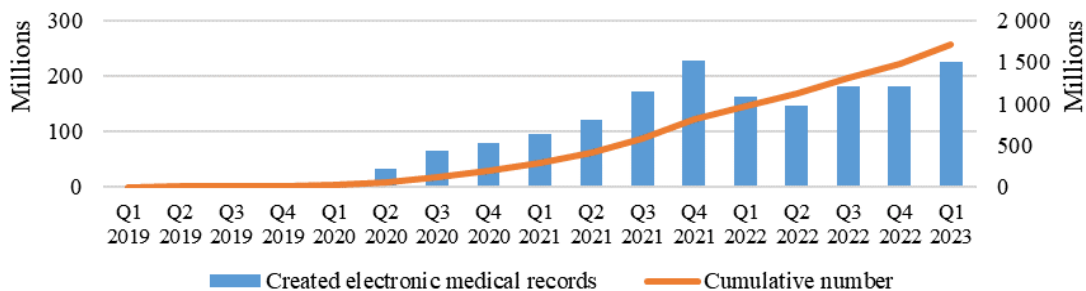


Figure 6. The dynamics of electronic medical records in Ukraine

Sources: developed by the author based on (The National Health Service of Ukraine, 2023).

One of the most numerous groups of medical records is created and executed medical referrals (Figure 7). During the 2020-2023 period, there was an increase in both quantitative and qualitative indicators of electronic

medical referrals. At the end of the 1st quarter of 2023, the number of created medical referrals reached almost 280 million units, and the share of performed referrals for the 2020-2023 period rose from 31% up to 70%. This indicates the system improvement, reduction of errors and wrongly created referrals.

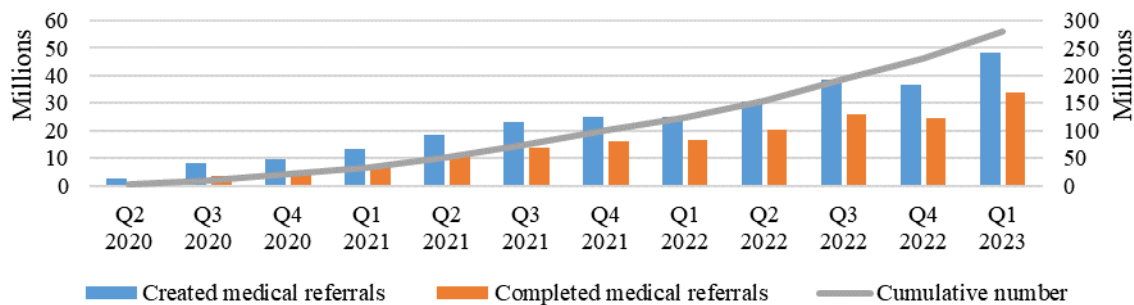


Figure 7. Indicators of electronic medical referrals in Ukraine

Sources: developed by the author based on (The National Health Service of Ukraine, 2023).

From June 2021, the system of electronic medical reports on temporary disability began to function (Figure 8). At the moment, these documents are created exclusively in electronic form. However, from Figure 8, we can see a significant reduction in the total number of such documents issued from March 2022, which is associated with full-scale military operations, evacuation of people abroad, decrease in the total number of economically active population in Ukraine and increase in population share with remote employment.

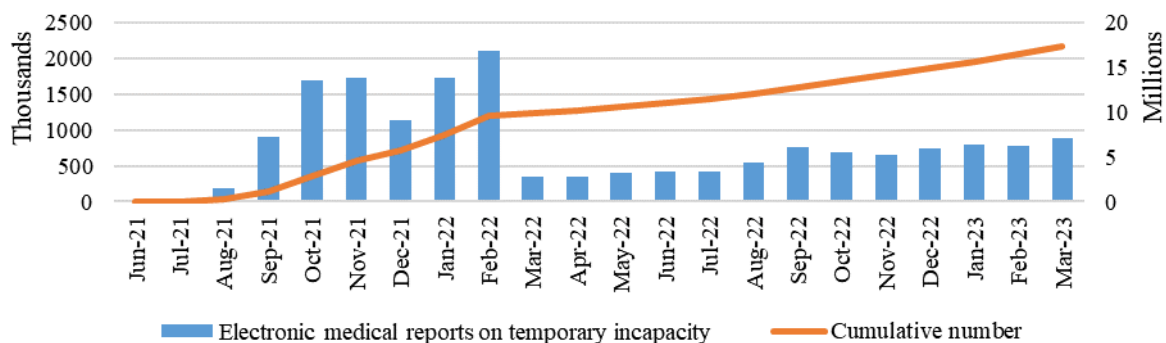


Figure 8. Electronic medical reports on temporary incapacity in Ukraine

Sources: developed by the author based on (The National Health Service of Ukraine, 2023).

In the post-pandemic period, along with the growing dynamics of the digital health market, much greater attention is paid to state supervision and regulation of this market segment. The issues of preserving data confidentiality, providing remote access to health data, and ensuring proper data protection are particularly relevant. In EU countries, data protection issues are regulated by the EU General Data Protection Regulation. This regulation was adopted as a basis by the World Health Organization (The Economist Intelligence Unit, 2022).

In healthcare, as in other types of activities where digital technologies are used, cyber protection is relevant. Resistance to cyber threats depends not only on the technological and security parameters of electronic healthcare systems, but also on the awareness of system users regarding security rules in cyberspace.

Another problematic issue of HealthTech implementation is the mass coverage of patients, the involvement of vulnerable groups, in particular the elderly, overcoming the digital divide. If a person does not have a smartphone or is not sufficiently aware of digital literacy, he will not be able to use the services of electronic appointment with a doctor, receiving electronic prescriptions or other benefits and opportunities of HealthTech. Thus, like all digital services, HealthTech is directly related to issues of digital literacy and the digital divide.

Summarising the conducted research results, we state that HealthTech has positive economic, social and environmental consequences for communities. HealthTech helps to reduce costs, accelerate and increase the

efficiency of interaction between patients and doctors. During pandemic or other emergency situations, the availability of electronic health records makes it possible to seek medical care remotely or at another location and receive medical care based on the medical history, treatment plan and other medical data about the patient entered into the electronic medical system.

Conclusions. The COVID-19 pandemic caused a significant acceleration in implementing the healthcare digital technologies. Today, the HealthTech industry is represented by a wide variety of technological solutions, including hardware, software components and services, which are used in diagnosing, treating and supporting patients as well as ensuring resilience of supply chains. During the pandemic, digital health technologies were a way to adapt and increase the resilience of healthcare systems to new challenges, support diagnosing and treating patients via telemedicine. In the post-pandemic period, the digital health market continues to grow and develop. HealthTech is able to provide higher efficiency and effectiveness of healthcare systems due to lower costs, increased availability of medical services, increased flexibility and adaptability of systems. However, the achievement of these benefits is not possible without an appropriate ecosystem for the digital medicine development and resolutions of protecting personal data of patients and increasing the coverage of the population with HealthTech services.

Conflicts of Interest: Authors declare no conflict of interest.

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Олена Пахненко, к.е.н., доцент, Сумський державний університет, Україна

Томаш Пудло, кафедра управління виробництвом, факультет машинобудування та мехатроніки, Західнопоморський технологічний університет у Щецині

HealthTech у забезпеченні стійкості громад у постпандемічний період

Пандемія COVID-19 призвела до посиленого впровадження цифрових технологій у сферу охорони здоров'я. За переконанням більшості дослідників, це сприяло підвищенню стійкості медичних установ, систем охорони здоров'я та громад до викликів, спричинених пандемією. Динамічний розвиток HealthTech продовжується і у постпандемічний період. Метою статті є узагальнення сучасних напрямків розвитку HealthTech, аналіз основних закономірностей розвитку ринку цифрового здоров'я в Україні та світі, дослідження можливостей використання HealthTech для підвищення стійкості громад і системи охорони здоров'я до природних та техногенних надзвичайних ситуацій. У статті проведено систематизацію типів HealthTech за компонентами, видами технології та етапами впровадження. Визначено, що в сучасних системах охорони здоров'я знаходять застосування усі базові цифрові технології: інтернет речей, штучний інтелект, BigData, AR/VR, 3D-моделювання та інші. Специфічними напрямками застосування цифрових технологій в охороні здоров'я є телемедицина, пристрої для носіння, що фіксують дані про здоров'я, спеціалізовані мобільні додатки тощо. Проведений аналіз розвитку світового ринку цифрової охорони здоров'я дозволив виявити найбільші обсяги та динаміку зростання ринку цифрового здоров'я в європейському та північноамериканському регіонах. За типами технологій найбільша частка інвестицій спрямовується в mHealth та телемедицину. За компонентами розвиток ринку цифрового здоров'я є рівномірним. У статті спрогнозовано обсяг глобального та європейського ринку цифрового здоров'я на 2024 рік. Розглянуто розвиток української Електронної системи охорони здоров'я, у якій фіксуються електронні медичні записи щодо створених та виконаних медичних направлень, обстежень, процедур, діагностичних звітів, планів лікування, медичних станів, створених електронних рецептів; записи про вакцинацію; медичні висновки про тимчасову непрацездатність та про народження. Виявлено скорочення динаміки внесення електронних медичних записів в систему з березня 2022 року у зв'язку з повномасштабними воєнними діями в Україні. Технології digital health сприяють підвищенню ефективності та результативності систем охорони здоров'я за рахунок зниження витрат, підвищення доступності медичних послуг, збільшення гнучкості та швидкої адаптивності цих систем. Досягнення цих переваг повинно супроводжуватися забезпеченням захисту особистих даних пацієнтів та чіткою регламентацією рівнів доступу до цих даних, а також мінімізацією цифрових гепів та максимальним охопленням населення послугами HealthTech.

Ключові слова: цифрове здоров'я, цифрові технології, ФінТех, охорона здоров'я, віддалений моніторинг пацієнтів, телемедицина.