Modern Medical Information Technologies: Implementation Issues and Development Vectors

Oksana Tur[a], Viktoriia Shabunina[a] and Anastasiia Tur[b]

[a] *Kremenchuk Mykhailo Ostrohradskyi National University, Pershotravneva str., 20, bldg. 3, Kremenchuk, 39600, Ukraine*
[b] *National Pirogov Memorial Medical University, Pyrogova str., 56, Vinnytsia, 21018*

Abstract

The article contains analytical data concerning peculiarities of implementation of modern information technologies in Ukraine and regulatory and legislative regulation of their use. Some modern domestic medical information systems and possibilities of their interaction with eHealth have been investigated. Besides, such standards of exchange, management and integration of electronic medical information as HL7 and CEN/TC 251 have been studied. The authors have identified the problems of using the Picture Archiving and Communication System (PACS) and found out the features of the standard for the transmission of digital medical images DICOM 3.0 (Digital Imaging and Communications in Medicine). The positive dynamics of the growth of mobile applications in the health care field has been noted and information technologies further development trends in the medical field have been outlined

Keywords 1

Health care system, information technologies, medical information systems (MIS), HL7, CEN/TC 251, DICOM 3.0 (Digital Imaging and Communications in Medicine), Picture Archiving and Communication System (PACS), mobile applications in the health care field

1. Introduction

Digitization of all segments of people's life is currently the main trend of modern society. The digital transformation of society as a transition from the industrial era and analogue technologies to the era of knowledge is characterized by digital technologies and a variety of innovations. It's also the driving force of such transformations, as saving time and increasing productivity due to the automation of production and other internal processes of the company; optimization and improvement of communications; reaching a new level of customer service; competitive opportunities due to the improvement of the client experience and general optimization of the work process. Information systems (IS), designed to collect and process information, improve management and decision-making processes, are aimed at providing a wide range of services to both specialists and ordinary citizens. Therefore, IS are used in many areas of human activity. In the areas of their implementation, information systems make it possible to increase the efficiency of information support. Being actually an integral part of the society's life, IS affect the efficiency of the functioning of objects, and their correct operation affects the vital areas of activity such as financial, social, state, industrial, and business ones. Today, the use of IT is an important trend that characterizes the reform of the Ukrainian health care system and involves the development of new approaches to the analysis of its processes. Both in the medical and health care fields the use of advanced IT opens up new

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EMAIL: oktur@ukr.net (O. Tur); shabuninaviktoria@gmail.com (V. Shabunina); anastasiatur@ukr.net (A. Tur)
ORCID: 0000-0002-8094-687X (O. Tur); 0000-0001-7957-3378 (V. Shabunina); 0000-0003-4505-2042 (A. Tur)

opportunities for improving interaction between the patient and the doctor, improves the quality of medical care, and simplifies access to medical services.

In such conditions, the need for a comprehensive study of the effectiveness of functioning of information systems in medicine, the regulatory and legislative regulation of their use, as well as the development of a universal health care service, is beyond any doubt.

The aim of the article is to compare analytical data concerning peculiarities of implementation of modern information technologies in Ukraine and regulatory and legislative regulation of their use.

The implementation of the goal involves the following tasks: investigating some modern domestic medical information systems and possibilities of their interaction with eHealth; studying some standards of exchange, management and integration of electronic medical information; identifying the problems of using the PACS; founding out the features of the standard for the transmission of digital medical images DICOM 3.0; confirming the positive dynamics of the growth of mobile applications in the health care field; considering IT further development trends in the medical field.

2. Related Works

Many Ukrainian and foreign scientists have been recently focused on studying the problems of using information and communication technologies in the medical field. They showcase research and development in various areas of the health care system. So, while studying information technologies in medicine, Ye. B. Radzishevska and V.O. Vysotska pointed to their wide implementation areas, especially government bodies, regulatory framework, standards and compliance control, human resources, infrastructure, strategy and model for attracting investments [1]. D. H. Shushpanov investigated the socio-economic aspect of the 2016 introduction of the electronic register of the patients who need insulin therapy [2]. L. A. Cherednyk considered the peculiarities of the use of electronic information resources in the context of the transition to e-medicine. In particular, the scientist studied the possibility to make a declaration with a family doctor via the electronic health care system or to make an online appointment with a doctor, etc. [3]. D. O. Samofalov tried to carry out a comprehensive analysis of the state of public administration regarding the implementation and use of medical telecommunication technologies, and in particular telemedicine, for the universal coverage of medical services in Ukraine, as well as developing recommendations for its improvement [4]. Among the problematic issues of the implementation of medical telecommunication services, the author considered those related to the determination and systematization of assistance with the use of telemedicine technologies and the lack of a governmental position regarding the formation of a telemedicine network. He noted that the existing legal framework left quite serious gaps in the counselling through information and communication tools, some problems with checking these consultations and the possibility of patient's abuse of this resource, as well as some medical errors because of an incomplete clinical presentation of the disease [4]. Innovative technologies of inclusive medicine were studied by A. Yu. Zhukovska [5]. Information technology support and experience in using telerehabilitation technologies were considered by O. V. Palagin, T. V. Semikopna, I. A. Tchaikovskyi, and O. V. Syvak [6]. A. A. Tur and O. M. Tur investigated the modern medical discourse in the genre diversity of the communicative sphere [7]. Problems of the development of the health care system, associated with the need to use the latest technologies, also concerned the foreign researchers [8; 9].

The significance of the outlined issues has been confirmed by legislative acts. Thus, in 2013, the World Health Organization (WHO) together with six WHO regional committees adopted a number of resolutions on electronic health care and the use of information and communication technologies in this field. These resolutions became normative and legal acts regarding the provision of e-health in the field of work of both WHO and its member states [8].

The Resolution of the Verkhovna Rada of Ukraine dated April 21, 2016 approved Recommendations of parliamentary hearings on the topic: "On health care reform in Ukraine". The Ministry of Health of Ukraine, with the participation of the National Academy of Medical Sciences of Ukraine, was tasked with developing a draft of the concept of the state policy of informatization of health care of Ukraine, providing for the formation of the appropriate infrastructure, the creation of a national information and computer network in the field of health care, a branch system of databases,

and reference zones of informatization of health care in the regions. These institutions were also commissioned to continue at the tertiary level of medical care the complex implementation and development of telemedicine technologies with the maximum approximation of its diagnostic and consultation capabilities to the primary contact between a doctor and a patient [10]. During 2016-2020, the development of key processes and registers necessary for the existence of an information environment in the field of health care was started. Besides, the market of manufacturers of specialized software, which provide access to the central database of the electronic health care system and end-user support in healthcare facilities, began to form. The Decree of the Cabinet of Ministers of Ukraine dated December 28th, 2020 approved the "Concept for the Development of Electronic Health Care" [11], in which a number of problems were noted, in particular, the lack of compatibility of information and communication systems in the field of health care, the imperfection of information and network infrastructure and interaction between national registries, the imperfection of a number of registries, the lack of specialists for automation and change management, as well as computer and network equipment in health care institutions, the need for sustainable financial support and the development of effective international, interdepartmental and intersectoral interaction, etc. The level of computerization, high-speed Internet connection, digital competence of medical workers, as well as coverage of electronic medical information systems of health care service providers are insufficient. These problems, on the one hand, are a challenge, and on the other hand, they provide opportunities for rapid development, since there is no need to rework historically accumulated information and communication systems, and there is an opportunity to immediately join the development and implementation of the most modern information and communication technologies.

3. Proposed methodology/model/technique

According to a Frost & Sullivan report (Figure 1), the global digital health market is expected to reach $234 billion in 2023, up from $147 billion in 2019, with the health IT services segment accounting for the largest market share [12] So, in 2023 the growth is expected to reach 12.3%.

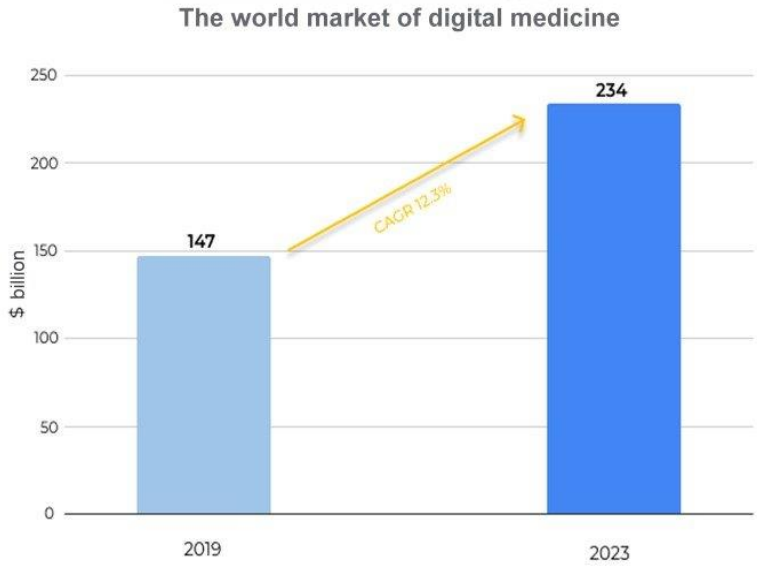

Figure 2: The world market of digital medicine

Both in the medical and health care fields the use of advanced IT opens up new opportunities for improving the interaction between the patient and the doctor, improves the quality of medical care, as well as treatment and access to medical data. One of the main drivers of such significant growth is the shift in the focus of the healthcare industry towards value-based, or patient-centred, medical aid, which closes the gap between what customers want and what the healthcare system can provide.

According to Deloitte, these new models of healthcare will be defined by advanced software solutions in the field of telemedicine, shaping the future of this industry in terms of prediction, prevention and personalization. Among these solutions are the following ones concerning to:

- Cloud Computing;
- radical interoperability and open platforms that make medical information more accessible;
- 5G (fifth generation) technology, designed for the most reliable support, with minimal delays and large-scale data transfer;
- artificial intelligence (AI) to improve diagnostic accuracy and treatment efficiency;
- natural language processing (NLP), which can be implemented in medical chatbots, to create detailed medical notes based on verbal or written requests;
- big data analytics, which helps to interpret medical images more accurately than practicing doctors do;
- Data as a Platform (DaaP);
- virtual reality as a safer alternative to drugs for pain relief and treatment of mental disorders;
- VR simulation of operations for its better planning and medical personnel training, etc.;
- robotics, wearable sensors and medical IoT;
- blockchain systems that help to combine data from multiple medical systems, pharmacies, streamline insurance claims, monitor and track supply channels for medical products, and much more;
- educational platforms [13].

A medical information system (MIS) is a specialized software developed specifically for the healthcare system and taking into account its needs. MIS differs from information systems in other industries in that it simultaneously stores and processes the patient's personal, demographic and medical information. MIS provides the functionality, which is necessary for a medical institution to interact with eHealth and the National Health Service of Ukraine. MIS developers provide a full range of opportunities for automating various processes in the clinic. With the help of MIS, a medical institution is able to carry out a variety of functions (Figure 2).

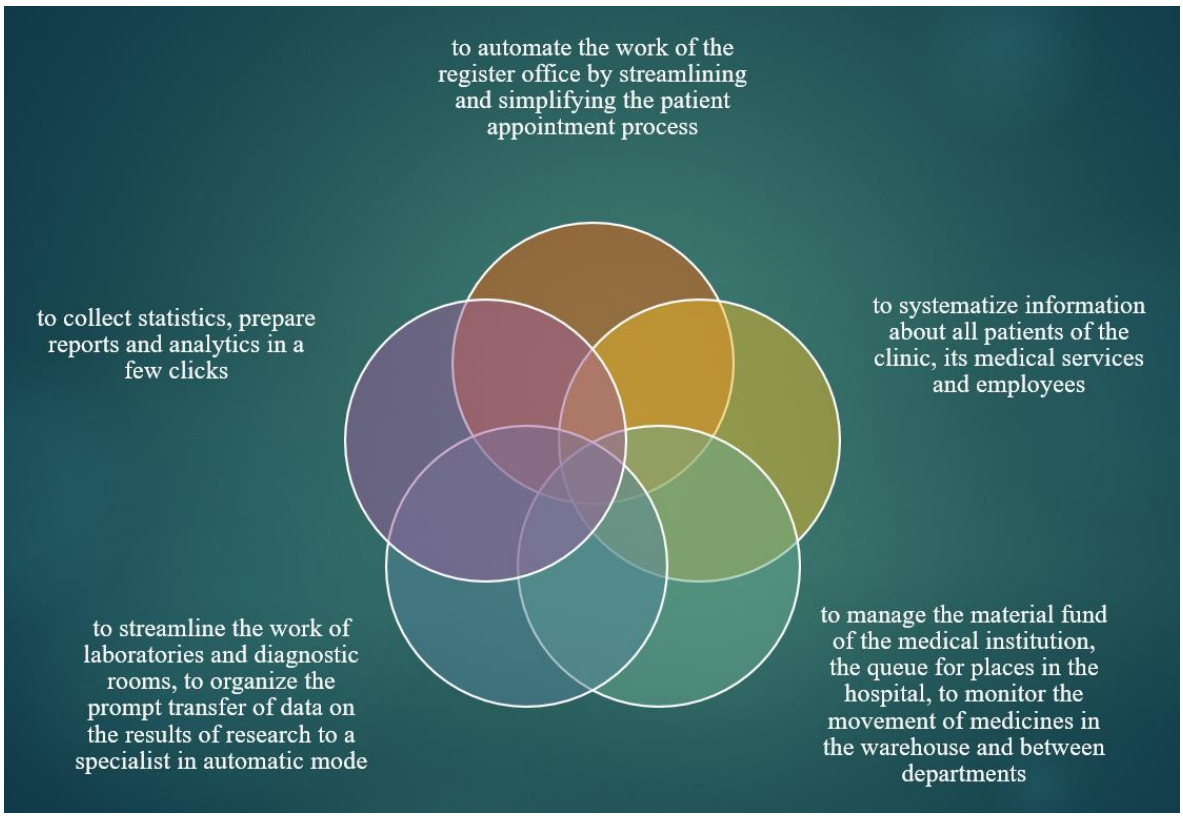

Figure 2: Functions of a medical institution provided with the help of MIS

Depending on the type of medical services for which the medical institution plans to receive funding from The National Health Service of Ukraine (NHSU), MIS should provide the ability to connect the following modules (Table 1).

Table 1
Some specific modules of a Hospital Information System

Module name	Module characteristics
1. Administrative module of the provider of primary health care services	for concluding contracts with NHSU and receiving funding by institutions providing primary health care
2. Workplace of a primary care physician	for the work of primary care physicians. The module involves working with declarations on the choice of a primary care physician, electronic medical records, issuing an electronic prescription under the "Affordable Medicines" reimbursement program
3. Administrative module of a pharmacy facility	includes functionality for registering pharmacies, their divisions and pharmacists as well as further conclusion of reimbursement agreements with NHSU
4. Pharmacist Workplace	for the work of pharmacists to pay off an electronic prescription under the "Affordable Medicines" reimbursement program
5. Administrative module of a provider of medical services of specialized medical care	for registration of a specialized medical care institution, and its divisions and users as well
6. SMC doctor's workplace	for the work of doctors providing specialized medical care. This module includes working with electronic medical records, diagnostic reports, issuing e-referrals, processing and repayment of e-referrals, maintaining electronic medical records of patient admission and discharge, as well as working with electronic medical records and e-referral of unidentified patients
7. Working with patient records	includes functionality for working with records of both identified and unidentified patients; joining the records of an unidentified patient to an identified one

Ukrainian medical institutions will be able to choose any medical information system from among those that have passed the inspection and have been connected to the central component of the "eHealth" system. The following IS are among the most common and used:

1. *Health24* is a fully functional cloud MIS, which combines functional services that ensure the work of a doctor and a medical institution in accordance with the existing standards of medical document management (Figure 3).

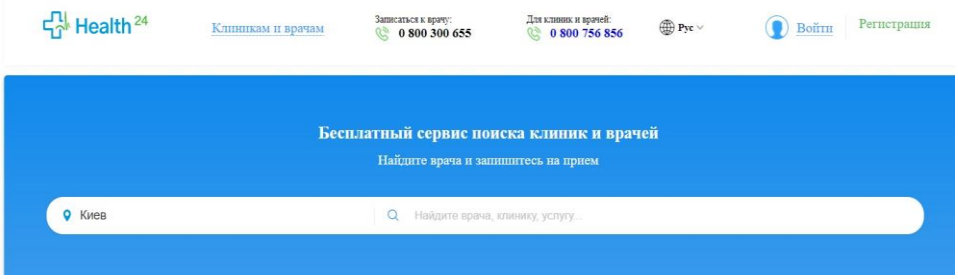

Figure 3: A medical information system Health24

2. *EMCImed* was developed in accordance with the standards of ISO and the Ministry of Health of Ukraine in order to ensure technical protection of information. MIS contains the following modules: electronic medical card of the patient, medical documents (medical registration forms of the Ministry of Health), medical staff, polyclinic and register office, hospital, laboratory (integration of laboratory equipment), warehouse and personalized accounting of medicines, statistics and reports of the Ministry of Health, services, contact centre, PACS, partners, online doctor appointment, and patient mobile application. Among the advantages are the ability to choose modules according to the organization's requirements, flexible configuration, and a powerful functional component. The system is protected thanks to the use of USB keys and encryption of all information. It also supports integration with other products, for example, 1C (Figure 4).

Figure 4: A medical information system EMCImed

3. *Doctor Eleks* is a comprehensive solution that optimizes the work of both private and public clinics of any size and profile. The developer is Eleks Co. (Lviv, Ukraine). This is the most widespread medical system in Ukraine, which has been operating since 2005. As of 2018, it maintains electronic records of more than 5 million patients. The system ensures the automation of key processes of a medical institution, in particular, keeping an electronic medical history, creating management reports and documentation in accordance with the requirements of the Ministry of Health. Additional features include a full-fledged editor for processing videos and images that can be added to documents, as well as a flexible technology for making reports. In addition, it is possible to conduct an audit of medical documents, the PACS module and the Web client are supported, and much more. Among the advantages are powerful functionality, a communication server for data exchange in HL7 format with adjacent IS, external laboratories, and insurance companies. Integration with Toshiba ultrasound is provided; import of DICOM images and connection of DICOM-compatible equipment are supported (Figure 5).

Figure 5. A medical information system Doctor Eleks

Among others, *Helsi* is a full-featured system for managing a medical facility. The functionality of the system is developed and adapted taking into account the specifics of the work and requirements of

the Ministry of Health, and is free for public institutions. *MC Plus* is a universal medical information system, the main component of which is the patient's electronic medical record, developed in accordance with the standards of the Ministry of Health of Ukraine. A feature of this MIS is the use of a process approach to the automation of medical and administrative activities of a medical institution. As of September 2020, with the help of the MIS MC Plus cloud solution, users could receive most of the services provided by the eHealth system modules, such as work with patient declarations, electronic referrals and medical records, providing or receiving an electronic prescription "Available drugs", registration of providers of primary and specialized medical services links, execution and maintenance of capitation contracts with the National Health Service, maintenance of electronic medical records (records of admission and discharge from hospitals are still under development), diagnostic reports, electronic medical records (EMR) and electronic referral (ER) for unidentified patients [14]. *Askep.net* is an international cloud-based SaaS solution for automating the work processes of medical institutions. It contains such modules as work with eHealth, patient card, polyclinic (appointment), hospital (maintenance of 066 and other forms), laboratory (test results), electronic prescription, statistics (internal and formation of official), specialized solutions (dentistry, maternity hospitals, oncology, dermatology, ultrasound, psychiatry, etc.), integration with third-party services and equipment, etc. A list of other medical information systems recommended by the Ministry of Health of Ukraine and information about them is available in [14].

Abroad the term HIS is adopted to use. It's a Hospital Information System for comprehensive management of all medical care processes, including the legal aspect. Some specific modules can be used as additions to it. For example, RIS (Radiology Information System) or PACS (Picture Archiving and Communication System). Separate types of MIS are Laboratory Information Management Systems (LIMS) and Pharmacy Information Systems (PIS). They can be partially or fully implemented as separate components of a complex medical information system.

Great Britain is one of the leaders of medical field informatization. However, it is specific that the medical systems of Scotland, Wales and Northern Ireland differ from those of England. Such fragmentation is planned to be overcome within the next ten years by integrating the health care and social care systems into the National Health Service of Great Britain [15].

The implementation of the pilot project of the European Union "Smart Open Services for European Patients" (2008–2014), within which information and communication services had been developed, made it possible to exchange medical data (medical history extracts, electronic prescriptions) among medical institutions of the countries of the European Union [16].

The United States of America is the country with the largest expenditure on health care. USA is also the leader in the informatization of medical services [17]. In 2009, the American Congress passed the law "The American Recovery and Reinvestment Act of 2009 (ARRA)", which encourages all healthcare providers to implement electronic medical records by providing appropriate payments [18]. In the USA medical services are provided by such companies as *Kaiser Permanente HealthConnect™*, which includes more than 430 medical facilities and 36 hospitals, joins more than 12,000 doctors, 140,000 employees and 11.8 million patients in eight US states and the District of Columbia; *Parkland Company*, which has 79 treatment and prevention facilities in North Texas; *Avera Health* (South and North Dakota, Minnesota, Iowa, Nebraska), *Mayo Clinic Health System* and *HealthEast Care System* (Minnesota) and others.

However, almost all researchers in the field of medical information technologies emphasize the heterogeneity, complexity and evolutionary nature of medical data, therefore there are problems of standardization of medical information, data exchange between some medical information systems, as well as the creation of a corporate information space of medical data. These problems are getting worse every time, because there is the need to enter and analyse an ever-increasing amount of medical information to provide quality medical care. Insufficient formalization (conceptualization and standardization) of this area, as well as the rapid progress of information technologies, hinder the solution of the above-mentioned problems. Nowadays, the search for conceptual solutions is increasingly associated with standardization, structuring, and ways of transmitting, archiving, and searching for medical information. In particular, standardization is designed to ensure effective interaction of regional, national and foreign educational institutions. We suppose if only standard software is used, medical institutions will gradually integrate into larger systems.

At the current stage Health Level Seven (HL7) and CEN/TC 251 (Comité Europnéen de Normalization / Comité 251) are undisputed leaders among developers of medical standards. Their standards claim wide international use.

The Health Level Seven standard is intended for electronic document exchange in healthcare facilities, especially those where the patient is receiving intensive medical care. It summarizes the work of a committee of healthcare organizers, manufacturers and consultants. Its purpose is to simplify the interaction between computer applications created by different manufacturers. The HL7 standard aims to create a free ad hoc standard opened to everyone who develops healthcare data systems. The term "Layer 7" in the title of the standard comes from the Open System Interconnection (OSI) Model adopted by the International Standards Organization (ISO). The HL7 standard satisfies the conceptual definition of application interaction adopted for the seventh layer of the OSI model. In the OSI conceptual model, the functions of the communications software and related hardware are divided into seven layers. The HL7 standard focuses on interoperability issues specific to the seventh or so-called application level. These include data determining, exchange timing, and application-specific transmission error reporting. Currently, the HL7 standard determines the interaction of various systems that send or receive data on admission / hospitalization of a patient, his discharge and transfer, requests for this data, orders, results of laboratory analyses and diagnostic tests, invoices for treatment, as well as changes in files, containing reference and regulatory information. This standard does not attempt to describe the data architecture within an application [19].

The European Committee CEN/TC 251 (Comité Européen de Normalization / Comité 251) was created to develop and implement data exchange standards between independent medical computer systems. It develops requirements for medical information structures to ensure internal data exchange between devices and information systems; data integration for multimedia presentation; external data exchange between departments and other legal users in any other medical sector. In addition, it develops requirements for preservation, safe transmission and storage of information. CEN/TC 251 standards are aimed at implementation in such countries as Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and Great Britain [20].

The HL7 and CEN/TC 251 standards currently account for 80% of the world's medical information space, but they are incompatible with each other. In order to eliminate this contradiction, as well as to establish closer cooperation and develop compatible standards for Europe and America, several meetings of specialists of these organizations were organized. An analysis of the approaches and technologies used by HL7 and CEN/TC 251 has proved the greater versatility of HL7 [21]. This conclusion is also shared by CEN/TC 251 specialists, who intend to change their own methodology for integration with HL7 [22].

In the modern world, where computer networks and multimedia tools have become quite affordable for many medical institutions, the problem of electronic exchange of medical images still exists. Back in 1983, the American Institute of Radiology (ACR) and the US National Electrical Manufacturers Association (NEMA) worked together to solve the problem by developing a digital medical image transmission standard. For this purpose, a joint committee was created. Its tasks included developing a standard that could ensure the digital medical images transmission, which would be independent of manufacturers of diagnostic equipment and contribute to the development of image archiving and transmission systems (PACS) and to their interaction with automated hospital information systems as well as to creation of databases containing diagnostic information obtained from a large number of remote devices of various types.

This standard was published in 1985. Its third version was released in 1991. It had been revised until 1993. It is called DICOM 3.0 (Digital Imaging and Communications in Medicine). The version was a significant step forward, since it could be applied in network environments using standard protocols. It described the levels of compatibility with the standard, the semantics of program commands and their associated data. The structure of the standard followed the guidelines of the International Standards Organization (ISO). All this contributed to the fact that such major manufacturers of diagnostic equipment as General Electric, Philips, Siemens, etc., have begun planning for their systems to enable DICOM 3.0 image exchange.

The German company Optiware has developed the Hipax software package, which focuses on the acquisition and transmission of medical images in the DICOM standard. The DICOM-3 standard

regulates the transfer of raster medical images obtained using various methods of radiation diagnostics. The DICOM standard formed the basis of the European MEDICOM standard, which was worked on by the working group WG4 of the technical committee TC 251 of the European Institute for Standardization CEN. Modern scientists believe that the use of the DICOM standard can bring tangible benefits to end users of medical images [23].

In medicine, it is extremely important not only to receive and transmit medical data, but also to collect, integrate, store, and process it, as well as to search for often contradictory, incomplete or heterogeneous information. Solving these tasks can ensure the accumulation of large volumes of data with the possibility of their further intellectual analysis. Therefore, the search for medical images is an integral part of the intelligent analysis of graphic data. At many hospitals modern medical information systems are equipped with Picture Archiving and Communication System (PACS) [24]. The great interest in the use of PACS in medical practice is associated, first of all, with a significant increase in the amount of information obtained in the image form.

The possibilities of searching medical images in PACS are limited, as the search is carried out according to the textual attributes of the image title (standardized description of the medical examination and its parameters, personal data of patients, etc.) [25].

In PACS medical images are stored, searched and transferred in DICOM format. But since medical images in DICOM format are large in volume, other graphic formats like JPEG, GIF, etc. are used for searching in the web environment. Another approach to medical image retrieval is content based image retrieval (CBIR). It is based on the detection of image features, image identification and determination of similar images, as well as their similarity degree [26].

The development of digital technologies has changed the process of providing medical care in many ways. Reorientation to patient-oriented service creates favourable conditions for the further development of information technologies in the field of health care and provides positive growth dynamics of this market segment. The COVID-19 pandemic has accelerated the convergence of patients and doctors with the digital healthcare technologies. Having significantly limited patients from interacting with doctors in an offline format, it has dramatically changed approaches to providing medical care. The main focus has shifted to the telemedicine used for remote visits. At the same time, the public concerned started paying more attention to digital media in order to receive information about COVID-19 and advice on their own safety. Similarly, the demand for applications, mobile sensors and digital media increased in order to get help in maintaining their health. In general, the pandemic has increased the need for medical support and remote monitoring of patients outside of traditional health care facilities, for patient self-monitoring through various connected devices and digital therapeutics that can provide medical care through the use of apps.

The company “IQVIA Institute for Human Data Science” in the report under the title “Digital Health Trends 2021: Innovation, Evidence, Regulation, and Adoption” has pointed out that along with the growing importance of the digital space in the health care field, there is an increase in investment. In particular, digital health investment reached a record $24 billion in 2020, with a new monthly record high of $3.4 billion in December 2020. This is due to the constant acceleration of mergers and acquisitions and the growing influence of private capital investors. A significant increase of deals on average to $45.9 million compared to $31.7 million in 2020 was also noted [28].

These trends are also being followed in the field of mobile technology to ensure impact on patient health. So, mobile application capabilities are being expanded. It is worth noting that, according to the report [29], the dynamics of changes in the structure of mobile applications available in the AppScript App Database have changed compared to 2015. Thus, in 2020, 22% of applications were focused on disease management compared to 10% in 2015, and the share of health management apps (especially exercise and fitness apps) decreased to 29% in 2020 compared to 40% in 2015 (Figure 6).

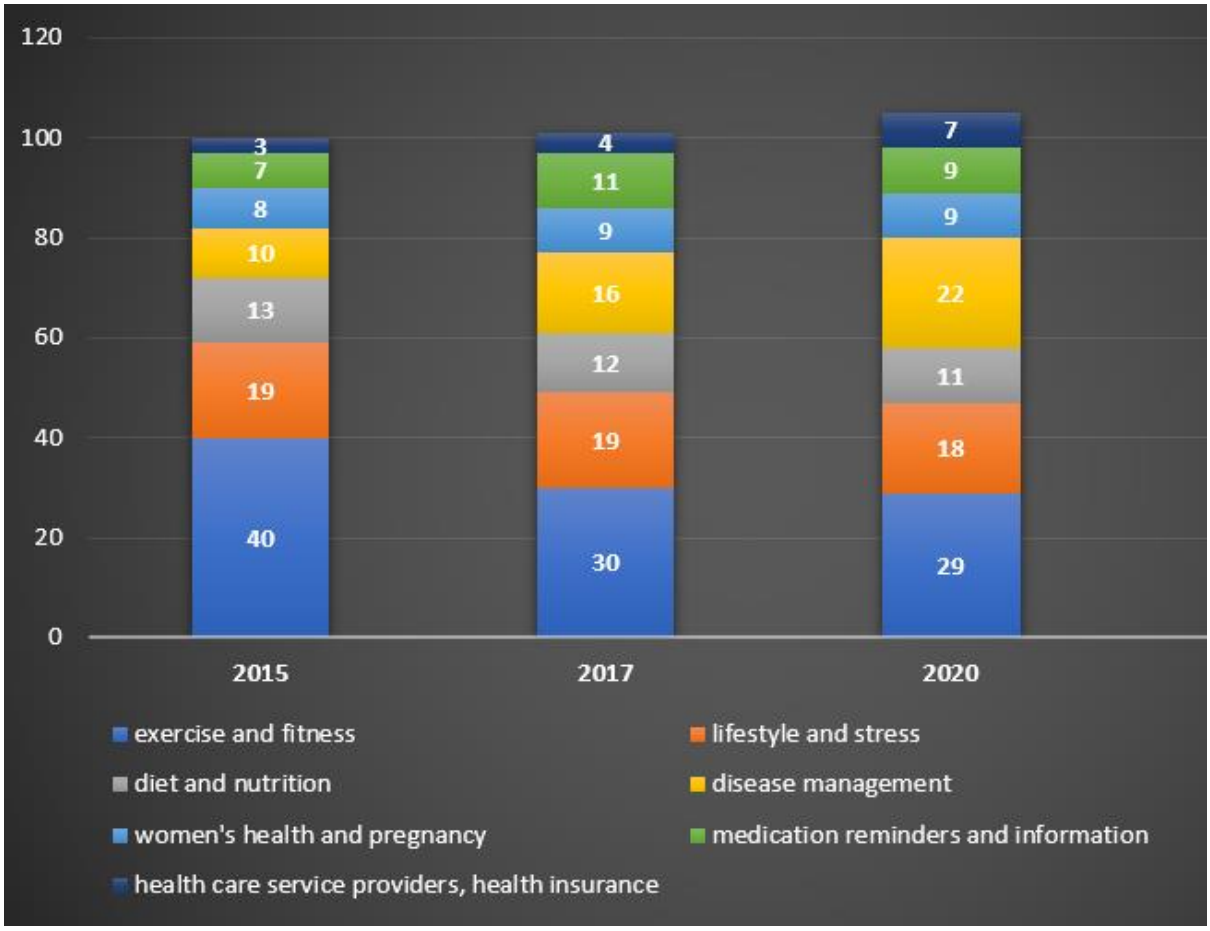

Figure 6: Dynamics of changes in the structure of mobile applications

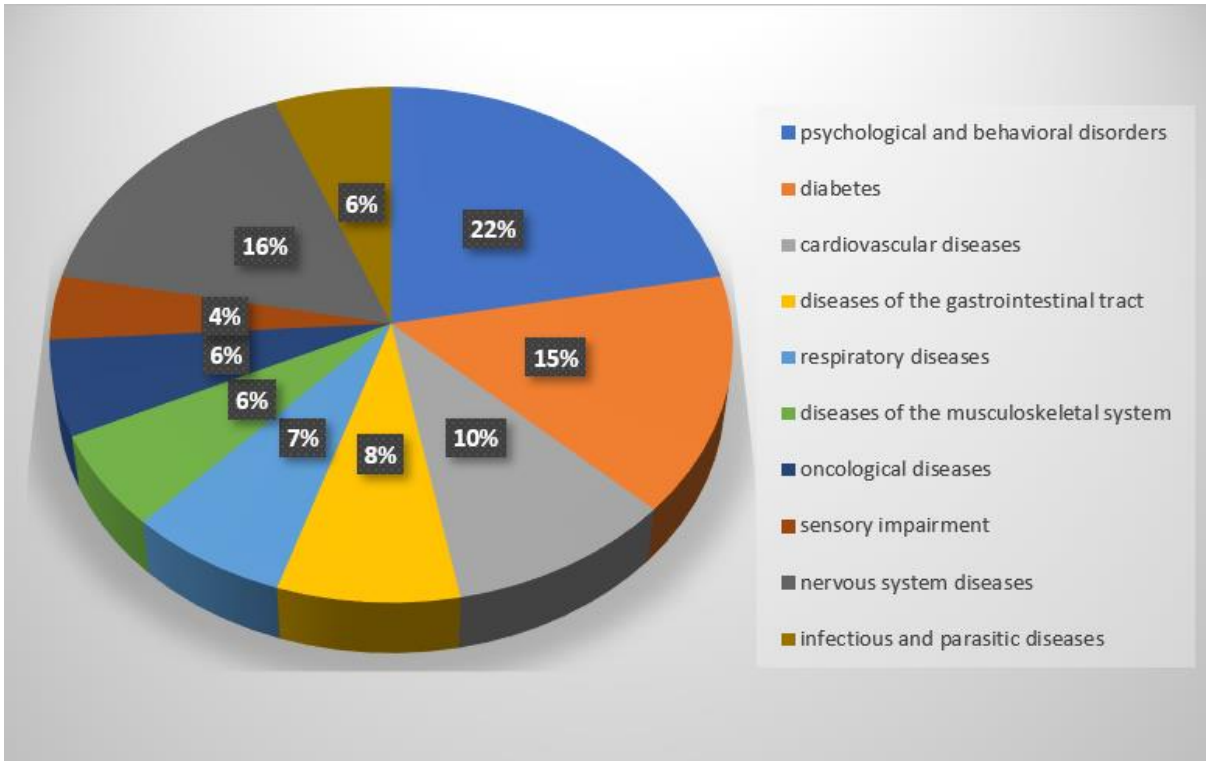

Figure 7: Specific gravity of applications used for various health disorders

Among applications designed for health management (Figure 7), the largest share belongs to the programs focusing on chronic diseases. In particular, the programs designed for patients with psychological and behavioural disorders (22%), with diseases of the nervous system (16%), and with diabetes (15%) dominate.

Although mental health and behavioural disorders are the leading category, demand for these applications has declined to 22% compared to 28% in 2017. Programs for patients with autism, panic, depression and anxiety disorders, as well as applications for "assistive and alternative communication" never stop being in demand. Applications used to manage disorders of the digestive, respiratory and musculoskeletal system, as well as cancer diseases make up a significant portion of programs designed to manage health. It's interesting that apps for patients with disorders of the digestive system have ranked among the leading categories for the first time, increasing their share from 4 to 8%. This increase is explained by the emergence of programs that help patients adjust their diet for irritable bowel syndrome and celiac disease. The specific weight of applications designed to control respiratory diseases, in particular asthma and chronic obstructive pulmonary disease, has also increased from 5 to 7%. Programs designed to manage genitourinary conditions, kidney disease, infectious and parasitic diseases have more than doubled in demand in the past few years. In addition, in 2020 a quarter of all applications for infectious and parasitic disease control, according to AppScript, were focused on COVID-19, demonstrating the dominance of the pandemic over other infectious diseases [29].

WebMD, which offers patients to learn about different conditions and their symptoms, and GoodRx, which helps to find a pharmacy with the best price on drugs are the most downloaded medical apps with more than 10 million installs. Besides, Governments have launched a number of apps to streamline the health systems and help with the reimbursement. There are, for example, Mobile JKN, Indonesia's national health insurance app that connects patients with providers across the country; MHRS Mobil, which is a centralized doctor appointment system in Turkey; L'assurance Maladie in France, etc. [29].

4. Conclusions

Undoubtedly, the development of digital technologies has changed the process of providing medical care in many ways. In 2021, the consulting company "Deloitte" in cooperation with "MedTech Innovator", which is at the forefront of the introduction of medical devices, the development of digital health care and diagnostic companies in the world, identified the main trends in the field of medical technology.

According to their report, by 2040, 2/3 of health care funding will have been spent to ensuring people's well-being and early detection, prevention and treatment of diseases. This is likely to be helped by adjustable sensor-controlled medical devices, which could form a large market for new medical technologies. The researches have pointed out that products of this market use advanced digital capabilities, which can make them particularly attractive objects for acquisition. Such healthcare product categories as artificial intelligence and machine learning (28%); mobile applications or platforms (18%), wearable technology (13%), sensors (11%), telemedicine (11%), IT in healthcare (7%) and big data or analytics (6%) have the best digital capabilities [29].

In order to provide proposals to the Project of new priority areas of scientific and technological development of Ukraine for 2021-2030, a study of the most promising scientific and technological areas in the field of medicine for Ukraine to achieve Sustainable Development Goal-3 "Strong health and well-being" was conducted. The results of this study have shown that wearable devices, 3D printing, smart technologies, health trackers, augmented reality and personalized medicine are the priority technologies in the world [30]. Scientific analytics has identified priority technological directions in the medical field, including virtual reality, 3D printing, robotics, artificial intelligence, augmented reality, the Internet of medical objects, wearable devices, smart technologies, and personalized medicine.

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