INTELLECTUALIZATION OF HEALTH CARE: OVERVIEWING INTELLECTUAL AND INFORMATIONAL TECHNOLOGIES IN THE HEALTHCARE SECTOR

Safonov Yu. M.

Doctor of Economic Sciences, Professor,

Macroeconomics and Public Administration Department

Kyiv National Economic University named after Vadym Hetman,

Kyiv, Ukraine

Borshch V. I.

PhD in Economics, Associate Professor,

Management and Innovations Department,

Odesa I. I. Mechnikov National University,

Odesa, Ukraine

Bashuk H.O.

PhD in Economics,

Public Institution of Higher Education

«Kryvyi Rih Medical College»,

Dnipropetrovsk Regional Council,

Kryvyi Rih, Ukraine

Abstract: The paper is devoted to the issues of intellectualization in health care and the problems of information processing in electronic monitoring technologies related to the healthcare field.

The main goal of this paper is to analyze the impact of the process of intellectualization on the development of management systems in the field of health care.

This study combines analysis of the concept e-Health and mHealth. In this study complex of the general scientific and special research methods were used to achieve the goal of the study. The method of logical analysis of the literature was used. The structural analysis was used with purpose to generate the hierarchical structure of system of medical electronic monitoring. Method

of summarization was used to make a conclusion. Scientific works of Ukrainian and foreign leading scientists in this sphere were used as the informational basis for the conducted research.

This overview can serve as the base for implementing modern intellectual and informational technologies in the healthcare of countries with developing economies.

Keywords: intellectualization, informatization, e-Health, mHealth, medical IoT.

Introduction

Modern economic development of health care worldwide is characterized by the transformation in the context of its intellectualization and informatization.

Trends of shifting from the industrial economy to the knowledge economy dictate new requirements for various sectors of the economy and areas of social welfare. Thus, the orientation of the world community on the innovative path of economic development a priori implies the dominance in the structure of its constituent factors of the intellectual and informational component.

Economic transformations, informatization and intellectualization processes of a society and economy, search for new ways to increase the organizations' competitiveness and their technological independence promote interest in developing effective means of their innovative development. Today a special place is occupied by the process of introduction of information and intellectual technologies in the practice of management in various spheres of economic activity and social welfare.

Modern healthcare trends have not escaped such trends. Global trends in healthcare management indicate the growing role of using high-tech developments not only directly in the process of providing health care, but also in the process of organizing, controlling and managing this area, aimed at improving the quality of health care, management processes at the medical institution and the effectiveness of its activities, in general. Thus, the effectiveness of these changes relies on a system-wide approach, reengineering, high-tech methods, and technological updating in the health care.

As a part of the implementation of a new course for the health care's development, which was launched on the beginning of XXI century, the use of information and intellectual technologies is given special attention by both theorists and practitioners. Since 2005, the World Health Organization (WHO) has started introducing e-health into medical practice after adopting the

special resolution WHA58.28. E-health plays a prominent part on e-Europe initiative (e-Europe).

Therefore, IT component in the field of health care, biomedical statistics, computer functional diagnostics, digital processing of biomedical signals, medical information (hospital) systems, artificial intelligence and medical expert system is very up-to-date.

But as for Ukraine, in the most cases, the intellectualization of health care management is intuitive, without the use of scientific, methodological and methodological basis, which determined the relevance of this study.

Thus, the main purpose of this study is to analyze the impact of the process of intellectualization on the development of management systems in the field of health care.

Materials and methods

In the research such methods were used as the mathematic modeling and the methods of formal logic, such as method of structural-logical analysis, statistical, graphic and systemic.

The information base of the study is the scientific works of leading scientists and practitioners on the intellectualization of the economy and health care system, WHO data, data from the State Statistics Service of Ukraine and the results of own research.

The object of the research is Ukrainian health care system and the transformation process of its management system on the bases of intellectualization and informatization. The subject of the study is the economic relations, arising in the process of introducing informational and intelligent technologies into the management system of medical institutions.

Results

Nowadays, technologies of the third platform (i.e. technologies coined by IDC that distinguishes the current IT environment of mobile, social, cloud and Big Data from earlier eras of computing [1]) is penetrating more and more into the field of electronic medicine.

Internet of things (IoT) forms the basis for subsequent changes in the healthcare system. Various sensors, analytical applications working with them and cloud technologies, as well as numerous mobile devices gradually change the existing approach to the diagnostics and prevention of diseases.

At the present stage of healthcare development in various countries, we can state the

beginning of the transition to the stage of comprehensive application of the instrumental model of healthcare oriented to the patient's needs.

E-health

E-Health forms the technological landscape, on the basis of which a qualitative transition to a new model can be made in the future. Currently, "e-health is a general term that includes the use of ICT in clinical medicine, education, management, organization, sanitary and epidemiological surveillance, research, information, prevention, and rehabilitation" [2].

E-Health is a system of cost-effective use of information and communication technologies to support the healthcare sector. It covers a range of health services and information and intelligence technologies, including telemedicine, remote medical counseling, mobile health (mHealth), electronic medical records or medical records (eMR / eHR), electronic prescriptions, big data, media and even artificial intelligence. Also, e-health includes user devices and applications related to the field of health or medicine, the use of which does not require medical supervision [3].

Thus, the role of e-Health is crucial in achieving key health priorities, such as universal health coverage (UHS) and the Sustainable Development Goals (SDG) [2].

According to [5], the level of implementation of e-Health technologies at the state level in the European space in 2016 was:

– Top 5 leaders (in descending order): Denmark, Sweden, Estonia, Slovakia, Finland;

– Top 5 countries lagging behind in the level of e-Health implementation (in descending order): Slovenia, France, Poland, Czech Republic, Ireland [5].

Later researches are not conducted.

Main components of e-Health are the following:

1) *Electronic medical records* (or *electronic health record*). It is a real-time longitudinal electronic record of an individual patient's health information, assisting health professionals with decision-making and treatment;

2) *TeleHealth* (including *telemedicine*). It involves the delivery of health services using ICTs, specifically where distance is a barrier to health care;

3) *mHealth* (or health through the use of mobile devices). Medical and public health practice is supported by mobile devices, such as mobile phones, patient monitoring devices, and other wireless devices;

4) *eLearning* (including distance education or learning). It is presented by the use of ICTs for learning;

5) *Continuing education in information and communication technologies* includes current methods for sharing scientific knowledge, such as e-publication, open access, digital literacy, and the use of social networks for health professionals, which help them to develop information and communication technology skills for application in health;

6) *Standardization and interoperability* refers to communication between different technologies and software applications for the efficient, accurate, and sound sharing and use of data, and requires the use of standards to make the integrated management of health systems viable at all levels [6].

E-Health uses such main technologies, as:

1) Internet;

2) AI (artificial intelligence);

3) Machine learning;

4) Image recognition;

5) IoT (Internet of things);

6) Blockchain [4].

The expert system must have 4 main blocks:

1) Knowledge base, which provides the accumulation of all medical definitions, symptoms, patient data, medical histories, analysis data and patient health indicators, etc.;

2) Data entry system;

3) Model of knowledge extraction;

4) A system of explanation of decisions, which provides expert decisions on diagnosis, treatment, dynamics and predicts further diagnostic situations [4].

The generalized system of components, technologies and blocks of e-health is presented in Figure 1.

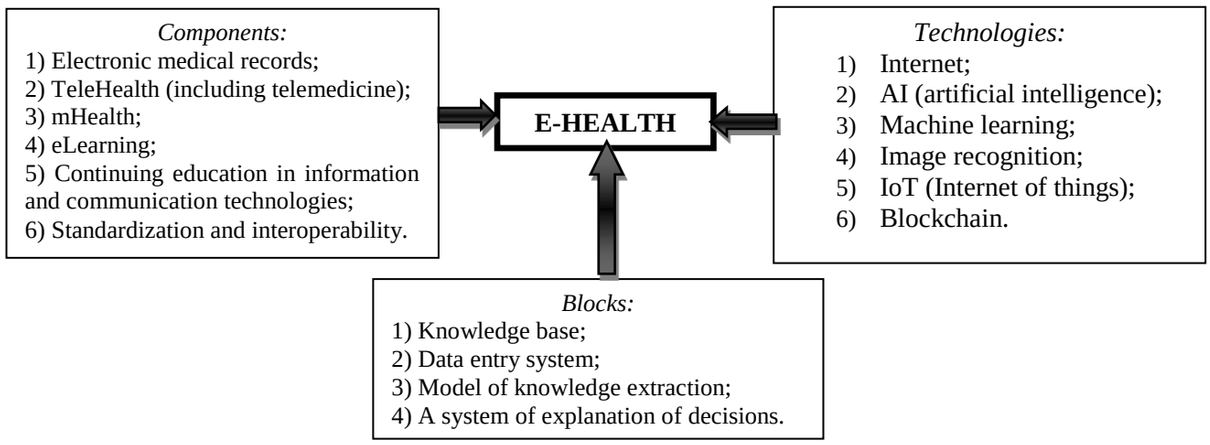

Fig. 1. Components and technologies of e-health. (*formed by authors*)

However, in our opinion, the use of intelligent and information technologies in the healthcare system is not limited to decision-making based on the processing of patient health indicators and decision-making based on the processing of analytical and statistical data. The following processes must be ensured: 1) making sound management decisions; 2) analysis and control over the implementation of financial and economic, medical and other activities of the medical institution; 3) accounting (accounting, management, etc.); 4) ensuring the conclusion of agreements; 5) storage of large amounts of information and automatic correction of the accumulated knowledge base.

E-Health plays an important role in the overall coverage of the healthcare system. The advantages of e-Health are:

1) It allows provide services to the population in remote regions and insufficiently informed communities with the help of telemedicine and mobile medicine;

2) It improves the training of health workers through the use of e-learning and makes education more accessible, especially for isolated regions;

3) It improves the effectiveness of diagnostics and treatment by providing accurate and timely information about the patient through electronic medical records;

4) It improves the operational and financial efficiency of health care systems [4].

B. mHealth and medical IoT

mHealth is a part of e-health, providing medical care and monitoring a person's healthy lifestyle using wireless telecommunication technologies and mobile devices.

mHealth is a technological, medical and social "silent revolution", taking place now, which

sooner or later will significantly affect all health care in whole. Predicted by many, the era of “four P” in medicine (Predictive, Prophylactic, Personalized, involving personal involvement or involvement of the Patient) will be based on mobile medicine and will become impossible without close cooperation between the patient and the doctor through technological solutions.

World Health Organization Health in [7], 2011, officially identified mHealth as an important “service delivery tool for public health”. According to WHO, to the main tasks mHealth include: (a) expanding access to quality health care services, including sexual and reproductive health; (b) ensuring reduction premature non-infectious mortality diseases, as well as increasing global health safety [7]. Thus, mHealth technologies confidently take significant position in the arsenal of electronic health tools.

mHealth includes hardware solutions (smartphones and devices for obtaining information about the state of the body, such as analyzers, fitness trackers, etc.), mobile applications (mainly for iOS and Android) and telemedicine services, which together form a complete patient remote support service.

Mobile technologies already widely represented in the e-health segment can be divided into several functional categories. The first category represents the functions of health monitoring, diagnosis and patient care. Devices and applications in this category include: (a) pressure monitoring systems, brain function, wakefulness and sleep rhythms, heart work, etc.; (b) multiparameter monitoring systems; (c) systems of remote interaction with a doctor or medical organization; (d) diagnostic systems, including systems for rapid analysis of blood, urine, saliva, respiration, etc.; (e) chronic monitoring systems for people with disabilities, elderly and children; (f) mobile and cloud-based health monitoring applications, drug monitoring, treatment planning, etc.

Sensors that are used in modern solutions of wearable electronics, can significantly affect the quality of life and its duration for patients of various groups, as well as provide significant assistance in the diagnostic processes, rehabilitation and treatment.

The second category is related to mobile technologies in e-health and includes devices and applications designed to maintain a healthy lifestyle. The market for devices in this category is developing much faster than the previous one. The reason lies in the regulation that characterizes the medical industry. Indeed, to begin mass application of the device, numerous testing, testing, clinical researches the certification is needed. If technological solutions of the first group are

almost impossible to use without the supervision of a doctor, then solutions to maintain a healthy lifestyle are available to every consumer. Also, such solutions are often used to form the optimal treatment method.

The second group is presented on the market in the form of a wide variety of products, including physical activity trackers, sports watches, wearable sensors / heart rate monitors, as well as applications for these devices and stand-alone applications with similar functionality. Existing solutions are capable of monitoring various media health parameters.

It is interesting that already today there is a tangible demand for solutions that allow you to track a person's route and notify emergency response services about dangerous situations. Today there is *Corvus-Tracker* application for the Android operating system, which is designed to track users' mobile devices. The application sends data about the user's location on the monitoring system server. The system is also equipped with the function of sending SOS messages to the phone numbers specified in the settings. Additional system functionality allows you to create geo-zones, work on a given time, combine several users into one group, visualize system data for the user, etc.

In the future, it is possible to switch to multi-parameter sensors of medical parameters capable of collecting a sufficiently large amount of information about the patient's health status, including and through integration with other wearable devices.

The possibility of additional use together with this sensor of any technological solutions from the field of mobile healthcare will significantly increase its potential. Medical information from such sensors will be transmitted to medical institutions, and the devices themselves will be used for communication and analysis of health data.

To build a medical electronic monitoring system, solutions related to cloud technologies have to be used. In this case, three service models can be distinguished:

- Software as a service (SaaS);
- Platform as a Service (PaaS);
- Infrastructure as a Service (IaaS).

Thus, different service models can be applied to different groups of customers. For example, the SaaS model can illustrate the provision of access to the system for medical professionals – employees of medical institutions. The PaaS model can be used when a medical institution wants to access an electronic monitoring system for further providing their services to patients.

Accordingly, the IaaS model can be applied to patients or their representatives who contacted a medical institution and want to use the electronic monitoring system.

The generalized structure of the described system is shown in Figure 2.

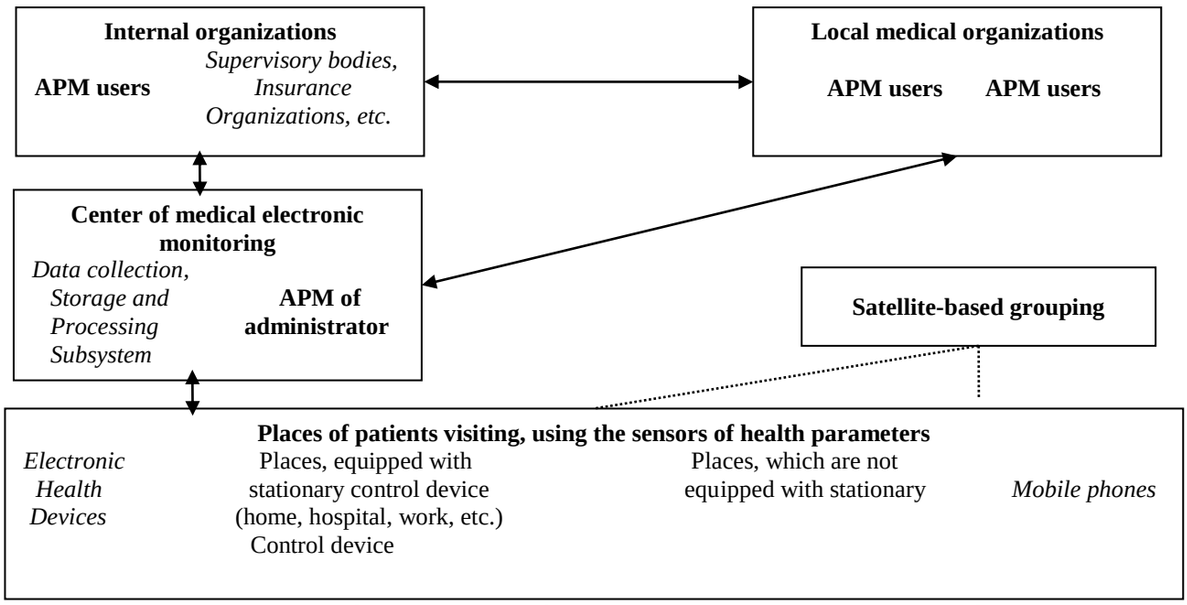

Fig. 1. Hierarchical structure of the system of medical electronic monitoring. (*formed by authors*)

The functionality of the medical electronic monitoring system is presented in table 1.

Table I. Functions of medical electronic monitoring system

The functionality of the medical electronic monitoring system	
1.	Collection of analytical data from information systems of territorial medical institutions for subsequent evaluation of patients' activities
2.	General analysis of statistical information for the subsequent assessment of the use of the medical electronic monitoring system
3.	Preparation of consolidated reporting
The functionality of the subsystem for collecting, storing and processing data of the territorial medical institution of the medical electronic monitoring system provides:	
4.	Maintenance of system directories, including registers
4.1.	Medical units of the electronic monitoring system
4.2.	Medical personnel for units of the patients' electronic monitoring system
4.3.	Inventory number accounting of peripheral hardware (with information about medical departments, medical staff and patients
5.	Collection of patient health data
6.	Display on an electronic map of the location of patients who have a life-threatening condition
7.	Distribution of medical recommendations by e-mail, SMS so on
8.	Providing voice communication between the medical operator and the patient
9.	Analysis of the patient's medical data for any time interval
10.	Ensuring control of the operability of system equipment
11.	Remote update of control unit software and workstations of system operators
12.	Formation of reporting information based on the contents of the database

Source: based on the own researches.

So, miniaturization of medical devices, cheapening, and receiving data in digital form, instantly transferring this data to smartphones, and from there via Internet to cloud-based information storages, made it possible to make available in everyday practice diagnostic and therapeutic procedures previously available only in specialized medical and preventive institutions. Thus the medical IoT is instrumental in providing health care.

Such devices, based on IoT, can transmit data via Internet and accumulate them in cloud storage (*Big Data*), which gives new opportunities for monitoring the physiological functions of the human organism, remote counseling of medical professionals, automation search for knowledge in this data (*Data mining*) [8].

It is important that the use of technological solutions of the IoT allows us to achieve lower costs for the healthcare system as a whole due to remote diagnostics and, accordingly, prevention of relapse of many diseases. In the future, the spread of e-health technologies will rely on new technological solutions in this category, and the development of technologies will have a significant impact on the economic status of the medical industry.

For example, in the United States, about 75% of medical expenses are for patients with various chronic diseases. The possibility of ongoing medical monitoring can seriously reduce healthcare costs. As of 2014, in the United States, about 3 million people used remote vital signs monitoring devices. Currently, a 45% CAGR (Compound Annual Growth Rate) is projected for this market segment. By 2020 the volume of this market in the USA has approached more than 20 million devices. Today, the majority of the US market is connected to cardiac monitors connected to the network (45% of the market) and solutions for monitoring patients at bedtime (18% of the market) [7].

Conclusion

E-health is in demand both by medical staff and by patients. Solutions of the medical IoT significantly reduce the medical burden caused by a large number of routine operations, due to which it is possible to pay more attention to diagnosis and treatment, and access to information in real time significantly improves the quality medical services and, in many ways, reduces the distance between the doctor and the patient.

In this case, the patient gets the opportunity to receive medical services simplified and professional monitoring of their own health.

Further development of medical electronic monitoring systems and large projects in the field of e-health should take into account the need for intellectualization of the system at the level of end users of the medical parameters sensor and ICS. Otherwise, the created IP will face congestion of servers and information transmission channels, as a result of which operating costs will increase, and the processing speed of collected medical data will decrease.

In the future, other components of the third platform, such as social networks and cloud solutions, will actively penetrate the e-health sector. The development of these segments of the third platform in medicine depends, first of all, on the creation of the e-health infrastructure, which will be based on electronic medical monitoring of the patient's health, the collection of information and its further transmission to medical institutions.

References

1. Stroud S. (2020) Third Platform. *Webopedia.* Retrieved from: https://www.webopedia.com/TERM/T/third-platform.html

2. Livanov V. M. (2012) Ot telemeditsiny k elektronnomu zdravookhraneniyu: evolyutsiya kategoriy. [From telemedicine to e-health: evolution of categories.] *Medical Almanac, 2,* 16-19. [in Russian]

3. Zaramenskikh E. P., Isaev E. A., Korovkina N. L. (2016) Intellektualizatsiya obrabotki dannykh v sisteme elektronnogo meditsinskogo monitoringa. [Intellectualization of data processing in the system of electronic medical monitoring.] *Mathematical biology and bioinformatics, Vol. 11, Issue 2,* 288-298. Retrieved from: 10.17537/2016.11.288 [in Russian]

4. Borshch V. I. (2018) Intelektualizatsiya upravlinnya v okhoroni zdorov″ya. [Management intellectualization at the health care.] *Actual issues of clinical and preventive medicine, Vol. 2, Issue 2-3,* 11-20. [in Ukrainian].

5. (2016) Atlas of eHealth Country Profiles. The Use of eHealth in Support of Universal Health Coverage. *World Health Organization.* Retrieved from: https://portal.ehealth.gov.ua/ (Accessed April, 12, 2020).

6. (2020) eHealth Components. *PAHO eHealth.* Retrieved from: https://www.paho.org/ict4health/index.php?option=com_content&view=article&id=80:compone

nts&Itemid=0&lang=en (Accessed April, 29, 2020)

7. (2011) WHO Global Observatory for eHealth. mHealth: new horizons for health through mobile technologies: second global survey on eHealth. *World Health Organization.* Retrieved from: https://apps.who.int/iris/handle/10665/44607 (Accessed April, 29, 2020)

8. Konstantinidis S. T., Billis A., Wharrad H., Bamidis P. D.(2017) Internet of Things in Health Trends Through Bibliometrics and Text Mining. *Stud Health Technol Inform, 235,* 73-77.