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ELECTRONIC MEDICINE: FORMATION AND SCIENTIFIC-THEORETICAL PROBLEMS

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This book highlights the essence, possibilities and formation of electronic medicine and the analysis of development trends and problems telemedicine. It focuses on scientific and theoretical problems of electronic health in details and reviews the development of health expert systems for physicians' decision-making, including the security of personal health information and Big Data problems in healthcare. Moreover, the book describes the opportunities of the Internet and social media in healthcare and their role in the integration of the people with physical disabilities. In addition, the trends existing in the provision of medical personnel and the formation of human resources in electronic health are commented.

The monograph is intended for a wide range of readers, as well for professionals, researchers, research fellows, teachers and students of information technology, healthcare and medical informatics.

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Contents

ABBREVIATIONS

ICT – information and communication technologies
EHC – electronic health card
IS – information system
E-medicine – electronic medicine
E-health – electronic health
MI – medical institutions
MIS –medical information systems
PMD – personal medical data
AI – artificial intelligence
IoT – Internet of Things
WHO – World Health Organization
ITU – International Telecommunication Union
EU – European Union
OECD – Organization for Economic Cooperation and Development
EHR – Electronic Health Records
EMR – Electronic Medical Records
IECP – integrated electronic card of patient
mHealth – Mobile Health
RFID – radio frequency identification devices
DSS – decision support system
MS – medical specialist
R&D – research and development
ES – expert systems

INTRODUCTION

Formation of information society, transition to a knowledge-based economy, and the introduction of information technologies in all spheres of social life have influenced the field of healthcare. At present, the daily activities in healthcare and medical field of a country are based on information and communication technologies (ICTs), and the need for the integration of ICT into healthcare has become an undeniable fact.

The use of ICT in health has created new opportunities for the development of this field, and at the same time, it has led to the transformation of the relationship between the traditional physician-patient-medical institutions in the healthcare system, changing the treatment-diagnostic and preventive methods and improving the processes of health monitoring.

Integration of ICT into healthcare has provided the citizens with high-quality and safe medical services, moreover, it is covering the other areas of healthcare, such as effective deployment of personnel, reporting on accounting and medical research, including the procedures of statistical data collection, protection, processing and transmission.

The progress in the informatization of healthcare system has led to the transformation of medical knowledge into the public wealth. A constructive solution to the problem of increasing demand for medical services is driven by the use of information technology in healthcare. These technologies constitute the basis for the improvement of healthcare system and solving the problems in this area.

The informatization of healthcare is being implemented in the Republic of Azerbaijan. "Azerbaijan 2020: Look into the Future" Concept of Development defines the reforms in healthcare system, improvement of legislative framework and management of healthcare system, and strengthening of innovative activity of scientific and medical potential of the country as major development trends of Azerbaijan. The Concept of Development also specifies the establishment of various medical electronic registers on the monitoring of the population's health, and electronic health card (EHC) system of the citizens and a single medical information system (IS).

One of the main directions of the "National Strategy for the Development of Information Society in the Republic of Azerbaijan for 2014-2020" is the formation of electronic medicine (e-medicine). In this regard, the following implementations are considered: establishing and developing National Health Network that ensures reliable and secure broadband Internet access of all medical personnel and medical institutions (MI); developing EHC system and providing all age groups with EHCs; expanding the application of medical information systems (MIS) and integrating it with the electronic health system; generating electronic health resources for general use; developing telemedicine; and increasing the knowledge of healthcare personnel in the field of ICT.

Provision of the citizens with high-quality and safe health services, provision of information support for medical research and uninterrupted medical education, and adoption of doctor's decisions and managerial decisions have required the introduction of the tools for the comprehensive informatization of healthcare.

Delivering timely and quality medical services to the citizens regardless of their place of residence and social status is one of the important social issues of the state. Due to the development of information, communication and health technologies, new trends in the provision of medical assistance to the population have been developed, which is successfully used by many countries in the field of practical healthcare. The advantages of introducing these technologies in clinical practice on the one hand, and the challenge of the modern time and existing traditions on the other, have been the main scope of discussions over the past decades.

In broader sense, electronic medicine (e-medicine) serves to handle the information flow through the use of electronic facilities to support healthcare services and healthcare management. The use of ICT in healthcare systems offers a new set of services that will eliminate the user's dependence on the place of residence, and due to this fact, e-health has become the key issue of the strategic planning in the field of healthcare.

ICT has shaped another public trend that affects healthcare professionals, as well as the healthcare system as a whole. The Internet, which is the key information source and a core infrastructure in the rapid, reliable and secure transmission, has led to the emergence of new realities in the healthcare. Consequently, e-health has been formed, which has introduced a set of tools that ensure the delivery of electronic protected information about the health of the people at the right place and time.

The working principle of collecting, processing, using, transmitting and storing electronic health information is based on the idea of creating uniform information resources that enable working with personal data of patients, as well as sharing such information with other HIs.

Transition to e-health implies the establishment of networks for both local and global transmission of health information, and the formation of a unique information space based on it. E-health infrastructure is a tool that supports both physician’s decisions and administrative decisions.

The presented book describes the essence, capabilities and scientific problems of e-health in details, and highlights the essence and main fields of telemedicine, and the capabilities, challenges and development trends of health expert systems (ES) for physician’s decisions. As one of the factors directly affecting the development of e-health, international experience is analyzed to address information security problems of personal medical data (PMD), and the development prospects are shown.

The role of social media in the integration and potential tendencies of Big Data in e-health, the opportunities and role of social media in the integration of disabled people into the society are described in this book in details. The situation in the field of provision of medical personnel, the new tendencies of ICT’s integration, as well as the international experience in the formation of human resources and e-health specialists are touched upon. Taking into account the world trends in the healthcare sector, the methods of coordination and management of demand and supply are presented to health professionals by referring to artificial intelligence (AI) technologies in the development of scientific and reasonable methods in staffing.

The first chapter deals with the factors and trends imposing the emergence of e-health, and tackles the terminological problems related to the definition of the notions "e-medicine" and "e-health", which are now referred to as synonyms and based on different approaches. International experience in the field of e-medicine and respective situation in Azerbaijan is reviewed, and the development trends of e-healthcare identified through solving problems requiring scientific support. In addition, the lack of sufficient scientific bases of the informatization of healthcare system is touched upon. The book provides numerous recommendations on the formation of e-health in Azerbaijan.

The second chapter outlines the role and application of telemedicine in e-health, the essence of telemedicine, its tasks and brief history, including its opportunities to provide patients with medical assistance, medical care and medical information through computers, the Internet and other communications technologies. The main fields of application of telemedicine, such as telemedical consultation, tele-training, tele-surgery, mobile telemedicine, and the functional capabilities of home telemedicine are commented. Detailed information on current telemedicine projects implemented in other developed countries, including CIS countries, and the development problems of telemedicine are presented.

The third chapter provides information on medical ES - one of the areas where information technology has been widely used since its inception. The rapid growth of knowledge, the diagnostic methods improved over the past decades, and the tendencies observed towards narrow specialization in modern healthcare have complicated making adequate decisions in the abundance of data. Therefore, this chapter shows the necessity of introducing modern mathematical methods, AI technologies and innovative approaches to provide the appropriateness of health decisions in various fields of medicine and to raise their efficiency. This chapter also deals with the technology for the development of such systems, the issues of knowledge engineering, and the transformation issues of natural medical intelligence into artificial medical intelligence. The information on the modern health ES and their development prospects, including health ESs developed in Azerbaijan is provided. Moreover, the recommendations are given special attention by the Azerbaijani government on the development of knowledge engineering for the formation of e-health and the training of knowledge engineers in Azerbaijan, and on enhancing the activity in the use of ES.

The fourth chapter explores the problems of PMD protection in e-health, and highlights the lack of proper protection of confidentiality and security of PMD, which is a major obstacle to the effective development of e-health. Approaches related to the security of health data of the patients available in the international practice is analyzed, and the specific features of PMD, the potential threats to safety and confidentiality of medical and physician secrets in MIS. The classification of the protection measures of PMD is described, and the goals and objectives of the legal, organizational, physical and technical (hardware) measures, as well as moral and ethical measures for the protection of PMD are explained. The importance of developing normative-legal documents regulating PMD protection in Azerbaijan is justified.

The fifth chapter outlines the factors that determine the high rate growth of health information, and shows that the emergence of ICT and network technologies has led to the collapse of the world with the information flow called "information explosion", and that information is generated on the descending rate. Given the fact that more than 30% of all data stored on the globe includes health records, and that this share is rapidly increasing, the specific characteristics of health data is studied, the essence of the Big Data phenomenon and its potential for e-health are defined. Big Data applications are systematized. The role and use of these applications in the following areas are presented: supporting doctor's decisions, standardization of doctor's decisions, establishment and development of individualized health, remote support for patient health monitoring, development of evidence-based health, supporting decision-makers on health management, shaping patient-oriented healthcare, the management of treatment of the patients with chronic diseases, as well as supporting administrative decisions. The advantages of Big Data analytics in the context of heath development and transformation, Big Data Analysis methods and techniques, the tools for its processing and analysis, including perspective trends of application, and the challenges restricting the use of Big Data are highlighted.

The sixth chapter provides detailed information on the devices connected to the Internet – Internet of Things (IoT) which has become an inseparable part of many HIS and has led to significant increase in the quality and accessibility of health services, reduction of the cost of medical care for patients, and even to the access to modern Internet services that allow patients to benefit from the recommendations of the best doctors and from the modern medical services in the areas where high technology equipment do not exist in hospitals. IoT's opportunities and applications in healthcare are thoroughly reviewed, and the practical issues in the field of health administration, medical diagnosis, remote monitoring, medication, drug therapy, treatment and care that have been successfully addressed, are studied. IoT services and applications that have an important role in e-healthcare shaping are described, and information on ICT that can respond to users (patient and physician) regarding the identification, monitoring and evaluation of the critical indicators of a person. This chapter also presents the dangers, risks and challenges for the physical safety of both patients and the confidentiality of their personal data when applying IoT solutions in healthcare.

The seventh chapter summaries the role of social media in the development of healthcare, and emphasizes the combination of social media with the interactive elements of new social technologies, such as multimedia, audio and text. Medical social networks, blogs, microblogs, wikis, media sharing sites and professional networks that offer numerous services (functions) are analyzed. The information about the opportunities of the use of social media by health professionals and e-patients is provided. This chapter also touches upon the conceptual documents and frameworks adopted by physicians to specify the ethic norms to be followed when using social media, as well as how to apply professionalism principles in online networks, to provide mutual trust in patient-doctor relationships, and to consider the interests of patients. Along with the contributions of social media for physicians, such as conducting consultations without leaving the place of work, discussing clinical situations with experienced colleagues, getting recommendations, watching interesting speeches at scientific conferences, and looking for a job, the obstacles and risk factors of social media in e-health environment are underlined.

The eighth chapter examines the possibilities of social media in the integration of people with limited health capabilities into modern society. The problems regarding information access, knowledge enhancement and integration into the society of the people isolated from these networks due to their problems related to full or partial loss of vision, hearing, limited mobility, cognitive disorder, and so forth, are reviewed. This chapter specifies the types, technologies, devices and software of social media, which ensure the people with physical disabilities with the opportunities to look for work, study, leisure, and so forth. In addition, the application and possibilities of mobile devices, Internet and modern web technologies, including AI technologies in the solution of the given problem are touched upon. The challenges faced by the people with physical disabilities when using social media are shown, and recommendations on their elimination are provided.

The ninth chapter deals with the international experience in the formation of human resources in e-health, and analyzes the practices the national schools succeeded in this area, and defines the human resources with necessary skills and knowledge as the main component for the integration of ICT into health.

The relevance of information technology specialties in the field of healthcare, particularly the problem of human resource deficiency in medical informatics is emphasized, and the challenges for the solution of this problem in the countries with advanced e-health are reviewed, and the programs and strategies adopted in the field of education and training of personnel for medical informatics are analyzed. The situation in the field of healthcare and integration of ICT in the Republic of Azerbaijan is commented and recommendations are put forward.

The tenth chapter examines the staffing in healthcare sphere, and shows a tendency to decline in staffing. The dynamics of staffing and personnel training in Azerbaijan are analyzed.

Approaches and methods currently used to evaluate the demand for human resources in healthcare are explored. It is shown that these approaches are based on the techniques of sociological surveys in line with the Initiative of the World Health Organization (WHO). Specific features of the medical specialists (MS) market and the evaluation factors of demand and supply are analyzed for the development of scientifically grounded approaches to solving the issue of regulation of demand and supply in the MS market, as well as for the identification of the situation of supply/demand, and for the proper managerial decisions in the emerging situation. Multivariate modeling of interrelationships between supply and demand in the MS market, and the statement and purpose of the intellectual management of supply and demand is presented.

The eleventh chapter proposes the methods of intellectual management of the regulation of demand and supply of MS based on fuzzy situational models and fuzzy similarity of situations. This chapter develops a technique for decision support on possible scenarios for the regulation of demand and supply in the recruitment of MS at health information, and describes problem solution algorithm and its implementation stages.

Evidently, scientific supply of e-health is not limited to the areas and ICT problems mentioned in this monographs. There are numerous multidisciplinary scientific problems in the informatization process of healthcare, and the future development of e-health depends on their resolution. Most of these problems are related to ICT's application in health. However, ICT's application in almost all spheres of human activity, including healthcare, creates other problems. These problems may include data overload, illnesses caused by ICT, lifestyle disorders caused by ICT, dependence on ICT and etc. In addition, formation of e-health necessitates expansion of research in this area.

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CHAPTER 1. ESSENCE, OPPORTUNITIES AND SCIENTIFIC PROBLEMS OF E-MEDICINE

At present, the daily activity in the field of healthcare and medicine in any country is based on information and communication and depend on their core technologies. The necessity of the integration of ICTs into health is increasing. It also deals with the provision of high-quality and safe medical services for citizens, reporting and accounting and medical surveys covering the efficient deployment of personnel, statistical data collection, protection, processing and transmission procedures. All of these, in turn, raise the need for comprehensive informatization of healthcare.

This chapter aims at the investigation of the factors and tendencies that shape the formation of e-medicine, the analysis of the essence and benefits of e-medicine, the analysis of the informatization of the tendencies and the identification of the major problems in the development process of the national e-health system [1, 2].

1.1. Factors and trends imposing e-medicine formation

WHO defines e-health as the use of ICT in medicine and health [3]. In a broad sense, e-medicine serves to improve the information flow by using electronic tools to deliver healthcare services and support health management systems [4]. The application of ICT offers a new set of services that will eliminate the dependence on the user's location [5].

The arguments supporting the application of ICT in the health and medical sector are already in sight for many decades. The experience of many countries shows that the advancement of e-health to the strategic planning in the field of health has been achieved due to the crisis in this sector which are provided by numerous factors [6]. These factors include:

- minor changes in the collection, storage and processing of data generated in the process of treatment of patients at the background of the wide use of high-tech equipment for the diagnosis and treatment of diseases;

- demographic processes: a) low birth rates, aging and an increase in elderly population in the developed countries; b) rapid growth in the young population in the developing countries;
- numerous cases where the content of the medical documents is unrecoverable or difficult to be recovered;
- opening several medical records of a patient in various polyclinics and diagnostic centers he/she applies due to the lack of information communications between the treatment facilities and the failure to ensure the confidentiality of the medical data stored on paper;
- wasting 40% of time by doctors and medical personnel for the documentation and search for the necessary information; errors occurring due to incompleteness or inaccessibility of medical information affecting the quality of the provided services [7];
- need for physicians’ decisions in the context of perception, coordination and analysis of large amounts of information [8];
- statistics of physicians’ errors which clearly demonstrate the gradual "deepening cracks" of the traditional model of the healthcare system [9].

At the same time, ICT has created a new public trend for the health workers and healthcare system, as a whole. The catalyst of this tendency is the Internet, which provides access to information and leads to the exceptional scale of communication between millions of people around the world [10, 11].

As a key source of information and a basic infrastructure for the fast, secure and reliable data transfer processes, the Internet has led to the emergence of new realities in medicine:

– medical knowledge has become accessible to everybody by attaining a new status, and the availability of numerous medical information on the Internet;
– relationships inherent to the real medical system are simulated in virtual space. Establishing contacts with the

patients through the Internet in the virtual information space enables establishing the virtual medical societies providing remote medical consultation, i.e., the interaction of the actors participating in the health system in the new reality is forming;

- tendency of transiting to the treatment at home has developed and is expanding, which involves the monitoring of the condition of the patient through the Internet;
- preference of ambulatory and preventive treatment compared to stationary treatment is one of the trends observed in modern healthcare;
- involvement of a citizen in the protection of own health and provision of the control of the patients at home, consultation of physicians and counseling have become one of the fundamental components of the reforms in health systems of the developed countries;
- provision of the doctors-specialists' services to the remote populations through the Internet will considerably reduce financial costs.

All these factors and trends, including the increasing need for public health services, have led to the integration of modern ICT into healthcare in the developing countries. ICT can be a driving force in addressing many serious problems and improving the healthcare performance without investing large amounts of money in this field. In this regard, medicine is one of the main implementation fields of ICT specified in the Action Plan of the World Summits on Information Society held in Geneva, 2003 and in Tunisia, 2005 [12].

1.2. Establishment of e-medicine

The development of the health services market and the introduction of ICT in this field have become a priority since 2000. G8 project on Global Health Governance (G8) in 2000 is the starting point for *eHealth*. As a next step, the resolution discussed in the 58th session of the World Health Assembly in

2005 and adopted by WHO, including the E-health concept should be mentioned. This resolution emphasizes an important role of e-health in increasing the quality of health care and improving the quality of health and health-related activities.

The challenges addressed to the states by the WHO on e-health include:

- development of strategic plans and legal basis for the implementation of e-health services;
- mobilization of participants and co-ordination of stakeholders;
- establishment of national centers for comparative analysis of activities and identification of best practice [13].

E-health and telemedicine has been included into the European Union (EU) agenda with the Lisbon Strategy at late 1990s. This political document has emphasized a vital role of ICT in the modernization of health. This strategy was later titled "E-health". In 2008, European Commission declared e-health as one of the six key EU initiatives [14].

The Organization for Economic Cooperation and Development (OECD) considers the application of ICT in medicine as a key driving force for economic growth, particularly in the developing countries [15]. The OECD believes that when telemedicine and telehealth are a part of the complex utilization of telecommunications and information technologies, their economic efficiency is significantly improved [16].

WHO Global Observatory for e-health has been set up to combine efforts by the world's medical community to informatize the healthcare [17].

1.3. The goal, essence and capabilities of e-medicine

E-medicine is based on the methodology proposed by WHO and the International Telecommunication Union (ITU) [13–15].

The objectives of e-medicine include:

- improving the quality and accessibility of medical services delivered to the population;

- reducing health resources and expenditures through improved governance;
- constantly informing the population about healthy lifestyles, prevention of diseases, provision of medical services for different purposes, and creating the opportunity for each citizen to control their health;
- eliminating the different types of discrimination (age, disability, poverty, etc.) in healthcare provision.

Person-oriented approach. The main priority of the concept of e-medicine is a person-oriented approach (Figure 1.1). The main objective of person-oriented approach is to direct all electronic services and databases to the patient. In other words, all the medical information of a certain individual is "connected" to his/her personal identity, and thereby, it is possible to access all this medical information available at any institution he/she applies to [17]. It dramatically changes the process of interaction between the patient and the medical institution, making it faster, more accurate and effective. All therapeutic and diagnostic processes of the medical institution should be informatized for the realization of the person-oriented approach.

In this context, e-health is a fusion of the distributed medical databases that provide a distinctive interactive consultation in the system of the relationships between "physician-to-patient", "doctor-to-doctor", "doctor-to-nurse", and "medical institution-to-medical institution" based on person-oriented approach.

Figure 1.1. Person-oriented approach [18]

b) Electronic health records (EHR) is an electronic analogue of a typical medical record (paper health history) of the patient and stores data from various sources: medical centers, hospitals, doctors, and laboratories (figure 1.2). Currently, the following terms are used: electronic medical passport, EHR or passport, electronic illness history, electronic medical records (EMR).

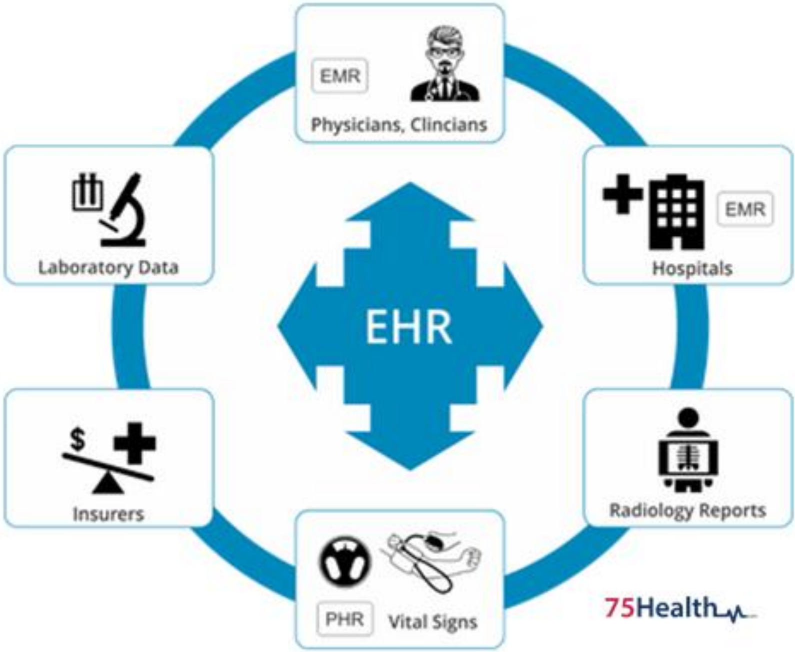

Figure 1.2. Electronic healt records [19]

EHR is a collection of individual (personel) medical information – PMD presented as electronic medical records about the health of the person (individual). EHR consists of general, clinical, biometric, social, economic, financial, insurance and other structured detailed information about the patient. It also ensures documentation of the medical services provided to the patients. EHR implies a medical document drawn up in a computer-comprehensible format and providing access to the adequate and accurate information for decision making and recommendations [20]. EHR aims at providing conditions for the continuity, consistency and quality of treatment, timely implementation of preventive and other measures to protect the health of a particular individual by documenting and maintaining appropriate medical information and its timely delivery to a competent medical personnel [20, 21].

It should be noted that the EHR of the patient is filled from birth, and this process continues throughout his/her lifetime. The application of EHR is required to ensure the accessibility of the non-contradictory, complete and operative data anywhere. At the same time, these data must be structured in accordance with the methodology for compiling medical documentation, capable to be interpreted in different languages, and support the decision-making in the appropriate place and time.

Using the EHR, physician gets access to the information needed for decision-making on the treatment of the patient. Moreover, physician spends less time filling in the patient's record and focuses on the immediate communication with the patient. As a result, the quality of medical services provided to the population is increasing.

The essence of e-medicine is the presentation of a set of tools that provide secure electronic information on the health of patients at the right place and time [22].

The working principles of collection, processing, usage, transfer and storage of electronic medical information are based on the generation of unified information resources that enable working with personal data of the patients and share this information with other medical institutions. Transition to e-health implies the establishment of networks for the transmission of medical information both locally and globally and the formation of a single information space based on those networks. E-medical infrastructure involves the tools that support both physician decisions and management decisions [23].

A global approach to support of treatment-diagnostics, medical-prophylactic and rehabilitation decisions made by physicians shows that the patient's electronic health records (medical records) constitute the "core" of e-medicine. Since the 80s of the last century, electronic health records (EHR), which enables the digitization of all health data of the patients, have been recognized as successful innovative technologies [20, 21].

At the same time, traditionally, one of the main tasks of the general practitioner is to compile the accounting records timely and properly. EHR also facilitates the work of professionals in this field [24]. EHR integrated on several healthcare facilities is a key element of e-health in many countries around the world.

The introduction of ICT into the healthcare system and the establishment of a single medical information space allows tracking the patient's health status and providing access to them, improving the quality of medical care and developing the administrative management. The introduction of e-health offers the following opportunities [25, 26]:

- remote monitoring of patients and better dissemination of information among the patients;
- provision of access to relevant electronic medical services for the disabled and the elderly and the population of remote regions and villages;
- continuous improvement of the healthcare system through more effective use of the latest health achievements;
- making more substantiated decisions on regulation, legal, financial, investment and research issues through the provision of access to different information;
- provision of patients' access to their electronic medical information at right time and place, and making reasonable decisions on care and treatment;
- provision of physician's access to all relevant information for more effective support and monitoring of the patient's health;
- provision of access to information on any disease, its prevention and treatment for doctors and patients
- provision of public access to medical information through the Internet or mobile telephony.

1.4. International experience in e-medicine

Currently, the healthcare system in entire world is being informatized. More than half of the world's states are operating in this field based on the methodology offered by WHO and ITU.

Obviously, the implementation of any international innovation program in a certain country is based on the selection of the model taking into account the national characteristics. From this point of view, although there is no rich international experience in the field of e-medicine, each country has developed its unique model. These models depend on the development, organization and financing principles of the healthcare in the country. The state plays a crucial role in the establishment of the e-medical system. That is, the state is the main investor in this field and responsible for the funds of the taxpayers.

Analysis of literary sources and the Internet publications shows that the introduction of ICT in the practical medicine is based on the implementation of the state programs and initiatives on e-health development in different countries around the world. These programs and initiatives include the organization of the electronic document circulation, the maintenance of the current status of electronic record of the citizens, the development of telemedicine and monitoring system of the public health, the generation of the Internet resources, and the personalized accounting of the medical services [27]. For example, EU-funded E-Health Action Plan 2012-2020: Innovative Health of the 21st Century program provides ICT solutions at national and transnational levels [28, 29]. The USA is implementing the "Integrated Development Program for Medical Sector" within the e-government and Canada is implementing the "Single E-medicine System Development Program" [30]. Within the framework of these programs, electronic health passport (record), personalized medical services, ICT infrastructure of e-medicine, e-document circulation, telemedicine, the establishment of inquiry data and classification registries are underway in the mentioned countries. At the same time, each of these countries has developed or is developing e-health strategies. Thus, 70% of the 53 member states of the WHO European Region have adopted the national e-health policies or strategies [29].

Some CIS countries are also taking active measures for the introduction of ICT in medicine in. The "E-health" program of the Russian Federation out of these countries is the most developed. Thus, the Federal Agency for Technical Regulation and Metrology approved the National Standard of "Electronic Medical Record", which defines the general principles, terms and definitions, structure and application fields, and adopted the concept of establishing a single state information system in the field of medicine [31].

Kazakhstan, Uzbekistan, Belorussia, Ukraine, Moldova and Kyrgyzstan have established the centers for the informatization of medicine [32–37]. The Republic of Kazakhstan adopted the "Concept of E-medicine Development" for years 2013-2020. The Republic of Kyrgyzstan has also prepared a draft Concept of E-medicine Development. Moreover, a draft law on the approval of the State program "Health 2020: Ukraine dimension" has been prepared. The "Concept of the Single Integrated Medical Information System" has been adopted within the framework of the National Strategy "Electronic Moldova". The Republic of Belarus adopted the "National Development Program for ICT Services for 2015", in 2011. Within this program, the "E-health" subprogram is implemented. Its main tasks include the development of electronic document circulation, the development of monitoring system of telemedicine and population’s health, and the creation of medical resources. Uzbekistan has also approved the National Concept for the Development of National Integrated Information System of healthcare in 2009 which describes the formation stages of e-health in the country in details. The Kyrgyz government approved a draft resolution on the approval of e-health program of the Republic of Kyrgyzstan for years 2016-2020.

1.5. E-medicine in Azerbaijan

Today, there are no separate conceptual and strategic documents on the informatization of medicine in Azerbaijan. The informatization processes of public health have been implemented based on the state programs "Electronic Azerbaijan (2003-2008)", "Electronic Azerbaijan (2010-2012)". Nowadays, they are being implemented in accordance with the conceptual documents as the National Strategy for the Development of the Information Society in the Republic of Azerbaijan for 2014-2020" and "Strategic Road Map on the Development of Telecommunication and Information Technologies in the Republic of Azerbaijan" [38, 39].

Within the framework of these programs and separate projects, EHR (for newborns) is provided (figure 1.3), exemplary medical information system is developed, online order of medical examination record is available (figure 1.4), and the registry of inquiry data and classification is created in Azerbaijan [40, 41].

Figure 1.3. Electronic health record [41]

Figure 1.4. Medical examination record [41]

In May 2010, Health Informatization Center under the Ministry of Health of the Republic of Azerbaijan was established in connection with the development of e-health in Azerbaijan. The Center is performing the central functions on the public monitoring and the general coordination and management of the Health System Informatization.

There are a number of technical and organizational challenges to be resolved for the application of ICT in the medical sector of Azerbaijan. Currently, the healthcare is not systematically informatized. Separate clinics are available where most business processes are informatized and local databases are created. These medical institutions digitally share the information about patients. However, the applied MIS are the products of various IT companies, which do not correspond to one another, and obviously, they can not share information within a single e-health approach.

Since the healthcare providers choose medical software themselves, the problems of inconsistencies are constantly growing. The lack of uniform methodological approach to data collection, processing and storage, and the absence of infrastructure and systematic information system do not allow for accurately evaluating the health status in the Republic of Azerbaijan.

On the other hand, serious issues have arose in Azerbaijan for the formation of e-health in line with the National Strategy. To address these issues, the National Health Network, which ensures the secure broadband network connection for all medical personnel, healthcare providers should be established and developed. Furthermore, EHR system should be improved and provided to all age groups; MIS's application should be expanded and coordinated with the eHealth; medical resources for general use should be established; tele-medicine should be developed; and ICT knowledge of medical workforce should be promoted.

The priorities of the "Strategic Road Map on the Development of Telecommunication and Information Technologies in the Republic of Azerbaijan" approved by the Decree of the President of the Republic of Azerbaijan dated December 6, 2016, include the "Development of Integrated Continuous Electronic Health Infrastructure". The health information system, which will be developed as a core component of this infrastructure, will incorporate e-health information, electronic registration, digital descriptions and electronic prescription components.

1.6. Development stages of medical information systems

The modern concept of information systems combines the medical records and financial data archives of the patients, the data from the monitoring of medical devices, automated laboratories and monitoring systems, and the availability of modern data sharing tools (e-mail, Internet, video conferencing, etc.).

Medical Records Institute, USA, distinguishes the following five levels of HIS from the computerization prism [42]:

Stage I. Automated medical records. This stage is characterized by the fact that only about 50% of the information about the patient is included in the computer system and provided to users in different reporting forms. In other words, this kind of computer system generates an automated circuit around the "paper" technology of information about the patient. Such automated systems typically involve the registration of patients, extracts, hospital transfers, diagnostic information entries, appointments, operations, financial issues, parallel to "paper circulation" and primarily generate different types of reports.

Stage II. Computerized Medical Record System. At this stage of HIS development, previously unentered medical documents (often in the form of print, scannograms, topographs, etc.) are indexed, scanned and stored in electronic storage systems (magnetic-optical discs). This type of TSS successfully started practically only in 1993.

Stage III. Electronic Medical Records. In this case, HI should develop an appropriate infrastructure for entry, processing and storage of information from the workplace. Users must be identified by the system and provided with the access in accordance with their status. The structure of electronic medical records is determined by the capabilities of computer processing. At this stage, electronic medical records can play an active role in decision-making and integration with the ES, for example, during diagnosis, when choosing medicines, taking into account the existing somatic and allergic status of the patient, and so on.

Stage IV. Electronic Patient Record Systems or Computer-based Patient Record Systems. At this development stage, the patient's records include more information. These records contain appropriate medical information about a particular patient, the sources of which may refer to one or more HIs. Such a level of development requires a single system for the public or international system for patient identification, terminology, information structure, coding and so forth.

Stage V. Electronic Health Record. This system differs from the electronic patient record system for almost unlimited number of information sources about the patient's health. Information on non-traditional medicine and behavioral activities (smoking, sports, diet use, etc.) is also available.

1.7. Scientific problems and direcions of e-medicine

International practice shows that today the scientific bases of the informatization process are not sufficiently developed. The scientific problems of e-medicine directly depend on the goals and tendencies of its informatization and the digitization of the information, organizational-management, treatment-diagnostics, personnel, resource, economics and other certain aspects of the medical institutions and aim at the solution of various issues. Some of these issues are related to the development of a general methodology for the informatization of the medical institutions, while the others require the development of specific issues related to the medical field [42]. These specific issues include the turnover of the electronic medical records and its standardization, the unification of medical information description, and the development of the architecture for the management system of software and database for medical applications, and mobile healthcare. In addition, the list of specific issues covers the development of electronic tools for sharing of the patient’s information; continuous analysis, assessment and forecasting of the information collected in the health information database; the clinical and management decision support in e-health environment; provision of medical information safety;

improvement of the quality of medical services; and extra costs reduction [43–45].

Below are some of the scientific problems arisen in different stages of the informatization process of medicine which are challenging for professionals.

Integration problems in e-medicine. The modern concept of ICT involves the collection of information obtained from different sources (medical records archives, results from laboratories, financial information, etc.) and the development of tools for data sharing.

Establishment and development of MISs and their integration in regional, institutional and national healthcare are quite multifunctional, complex and difficult issues [46]. Today, the theory, principles and methods of open systems are applied as the main integration tools [47]. In order to solve the problem of reconciliation of the information systems with different platforms, the agreed set of interfaces, protocols and data format standards should be used.

The MISs should provide the clinical and non-clinical data sharing by maintaining a semantic meaning. In this case, in addition to common standards, the specific health standards should be used for the solution of the problem of reconciliation. The formation of a single information space for clinical data should be based on the general classifications, terminology and communication standards.

Standardization problems in e-medicine. The standardization of the medical records in e-medicine, information sharing among different MISs is one of the most challenging problems in the world. The main difficulty is due to the availability of the excessive number of concepts and terminology used in modern medicine. According to the expert estimates, there are more than 2 million definitions and terms in this area. For example, the Oxford dictionary contains 615,000 words. At the background of the increasing exchange of various information about the patient, the use of terminology, electronic records, digital description standards and international classifications has become more definite. The key priorities for the coordination of different types and levels of MISs are related to the unification of national standards with the internationally accepted standards. From this point of view, the establishment of national standards supporting the medical document circulation on a single methodology, referring to the international standards is one of the topical scientific and applied problems in the field of medical terminology. In most developed countries, the *"Health Level Seven" (HL7)* standard is used for MISs, the *"Clinical Document Architecture" (CDA v.2.0)* standard - for the unification of the clinical document architecture, the *SNOMED (Systematized Nomenclature of Medicine - Clinical Terms)* standard - for medical terms nomenclature, and *DICOM (Digital Imaging and Communications in Medicine)* standard – for digital medical descriptions [48].

Security problems of personal data in e-medicine environment. The problem of information security in the medical field is distinguished by its specificity. This peculiarity is related to more sensitive and private medical data. Thus, e-medicine grounds on EHR that contains the information about the health of the individual. EHR is a MIS compiled in a computer-compliant way which provides the access to accurate and truthful information for making the necessary decisions and recommendations. Protection and safe transmission of PMD in the operation of these systems are directly influencing the development of e-medicine [49].

Security of PMD implies the protection of PMD from internal or external threats, transmitted or supported by electronic media and any other technical or communication devices, including their protection against leakage, theft, loss, unauthorized destruction, distortion, modification (counterfeiting), copy and blocking.

According to the international practice, solutions of security problems of MIS requires the provision of the followings: confidentiality (prevention of unauthorized access to PMD), integrity (provision of the reliability of the medical data information when sharing, protection against unauthorized modification of information), and availability (access to information and associated assets by the authorized users, including the resistance mode in case of excessive overloading of MIS) [50–52].

It is required to develop new scientific approaches and solutions to reliably ensure PMI's confidentiality [53].

Large-scale data problems in e-medicine. Modern medical institutions are generating large volumes of different types of data (Big Data). *Big Data* in the medical field is generated due to EHR, wearable sensors, stationary medical devices, results of various laboratory analyses; radiological images, statistical data collected for years in clinics, pharmacological relationships of the drugs, and decoded results of individuals' genome.

The development of mobile technologies and the Internet of Things has accelerated the growth of personal data [54, 55].

The quality of medical care depends on how efficiently the doctors, administrators and governing bodies use this information. *Big Data* technologies may be used to support treatment-diagnostic and organizational-management decisions [56, 57]. Increased access to medical data offers deeper understanding of the relationships that are created on the basis of large amounts of data collected from various data sets using *Big Data* technologies and to convert the latter into new knowledge. The analysis of *Big Data* may reveal unexpected mutual relationships or patterns beyond human capabilities. One of the major trends in this field is to manage the health status of a patient and to support clinical decisions taking into account the health information of the previous years, including the results of current laboratory examinations, demographic characteristics (age, gender, and ethnic affiliation), drug response and the retrospective information about his/her interactions with the medicaments. At present, the development of large-scale data analysis and summarization methods is one of the global challenges facing the scientists [58].

Software and hardware tools in e-medicine:

a) *Grid technology* in e-medicine is used to build an infrastructure that provides services for processing and integration of distributed bio-medical data. The EU e-medical system is widely using grid-technology. The creators of e-medical system explain the advantages of applying this technology by three main factors:

1) increasing the availability and quality of medical services at the expense of rapid diagnosis;

2) reducing the cost of medical services at the expense of early detection of disease;

3) reducing the medical errors and the selection of optimal treatment strategies through the use of computer programs that provide the access to the medical data [59].

b) *Cloud technology*. At present, information systems and information technology applications in the software and hardware architecture of e-medicine are based on the Client-Server principle. Whereas the use of cloud technology is mainly limited to hosting electronic medical information for small businesses (*SaaS* model). However, cloud technology has a wide range of medical opportunities.

Therefore, existing architectures are predicted to gradually switch to cloud technology. Cloud technology may enable the creation of more effective and transparent data infrastructure through the reconciliation of data processing centers and MISs of healthcare institutions. Storing the primary medical data in clouds can provide secure data sharing among medical systems [60]. For example, various healthcare providers can store medical information in cloud and share information and monitor the clinical data at real-time, and acquire analytical information on different clinical situations [61].

Information support for decision-making in clinical medicine. Information support for the diagnostic and treatment decisions in clinical medicine is of the global tendencies of e-medicine. A number of factors can explain this: 1) medical disorders are manifested in different forms, and therefore, there is no unequivocal criteria for diagnosis and treatment; 2) each disease is based on a large number of input indicators; 3) these indicators are qualitative and quantitative, and their values are characterized by inaccuracies. An experienced physician combines the baseline data with personal practice to confirm own hypothesis, taking into account similar situations in a particular situation, and identifies atypical forms of the disease, and finally, predicts the dynamics of the process. It necessitates the imitation of logical judgments on the treatment and diagnostic decisions based on the knowledge and empirical experience of the physician. Obviously, knowledge-based intelligent systems (expert systems, decision-support systems) are used to collect, store, manipulate, and evaluate the knowledge of experienced physicians-experts, and to identify and make adequate decisions for each particular set of data. The basis of these systems is the knowledge base consisting of cause-and-effect relationships in the specific subject area of medicine available as various rules that imitate the doctor's views, their possible causes and development duration, clinical manifestations, diagnostic evaluation of the observed symptoms.

The use of expert systems and decision support systems in most different areas of clinical healthcare may reduce the number of physician errors. These systems can be used to solve the following issues: assistance in the diagnosis process, search for case studies (precedents), therapy control and planning, images recognition and interpretation, and the monitoring of clinical and pharmacological properties (toxicity) of drugs [62, 63].

The development of medical intellectual systems is related to the solution of many scientific problems. These problems include selection of effective methods of knowledge acquisition from experts, the development of the methods for expert data processing, including the methodology for building knowledge base of the expert systems, the methods for analysis, evaluation and decision-making, advanced user interface, and the tools for the knowledge base editing and installation, including the visualization of the decision making process, analysis of results, their interpretation and explanation.

Research in the field of tele-medicine. One of the most important aspects of innovative healthcare is the development of telemedicine. These technologies provide remote consultation, examination, processing of primary information in highly specialized centers, and saving the time spent on examination, and increasing the accuracy of diagnostics. The research in the field of telemedicine is conducted in the following areas: remote monitoring of health indicators, the development of effective methods for the formalization and processing of medical data (descriptions and electronical signals (e.g. electrorecordiograms)); the development of the methods for the collection of distributed data and their rapid transmission to the integrated medical information system; the development of the methods and algorithms of data compression [64].

One of the dynamically developing trend of e-health is mobile telemedicine. Mobile telemedicine combines multiple satellite communication tools, mobile information technologies (phones, smartphones, and tablets) and various wireless communication technologies to provide wireless data transmission. Cellular telemedicine (mobile medicine) enables the patient to benefit from the remote treatment at home, uninterrupted tele-monitoring of the patient's health, and medical consultation [65]. The scientific problems of mobile medicine include the integration of sensors to various portable accessories and mobile phones, the different approaches to mobile monitoring of the patient’s health, and the accuracy and security of data acquired through wireless technologies.

***Systems supporting the living ambient of the elderly*.** At present, one of the global challenges is the aging of the world's population and the rapid increase in the number of people above 65. This process also increases the number of people suffering from the chronic diseases (arterial hypertension, heart failure, diabetes and memory disorders). This, in turn, contributes to the growth of healthcare costs.

The role of ICT solutions in the improvement of the quality of medical services provided to the elderly and in the partial reduction of health expenditures is rising. *Ambient Assisted Living (AAL)*, which supports the living of the elderly, has great potential for the development of individual medicine and the involvement of citizens in the treatment of their illnesses by using ICT [66]. The *AAL* system provides these people with medical transmitters, computers, wireless networks, software supplements, methods and services to support safe and healthy lives of the elderly and rehabilitating people [67]. The main objective of this system is to extend the lifetime through the use of ICT being more accessible to healthcare providers. Integration of the patients' EHR with the Internet-enabled smart-gadgets controlling the most important health indicators (sleep cycle, heart rate, pressure) allows physicians to monitor the latter in the real-time mode and provide telemedicine services [68]. Such systems can be successfully used for the rehabilitation and integration of people with disabilities into the community.

Physician-patient-medical institution relationship in e-medicine. The patient-oriented approach in the e-medical system has led to the transformations in the relationship between the physician and the patient. This problem, which is sufficiently actual, envisages the solution of a number of issues: the synthesis of the new system of relationships in the national health system; the impact of the new medical service market and the gradual transition of the physician-patient relations into the client-physician relations in the context of the formation of individual medicine on the quality of medical services and social and economic criteria; the development of the models for acceptable management of the patient-medical institution relations in e-medicine [69].

Human resource management in the field of medicine. The development of the scientific basis for managing human resources cover the following issues: monitoring of supply and demand for various qualified specialists in the field of medicine, their regional distribution and balancing, and the adaptation of medical education to labor market requirements [70–72].

Evidently, scientific support of e-medicine is not limited to the above mentioned trends and ICT problems. There are numerous multidisciplinary scientific problems in the informatization process of medicine. The future development of e-medicine depends on the resolution of these problems. Obviously, most of them are related to the application of ICT in medicine. However, the introduction of ICT in almost all spheres of human activity, including medicine, creates other serious problems. These problems are the medical problems of ICT, such as information overloading, illnesses caused by ICT, lifestyle disorders formed by ICT, and ICT addiction.

1.8. Scientific centers in e-medicine

Coverage of the scientific problems of e-medicine and the urgency of modernization of health have increased the interest of the international scientific community in the studies in this area. Specialized scientific centers have been established in a number of EU countries. Other states have included academic and research institutions in the list of priorities [63, 73].

The database of European priorities and strategies in e-medicine has been set up. This database covers e-medicine files from 27 EU countries, including Turkey, Iceland, Liechtenstein, Norway and Switzerland [74].

The goals of the database are to gather, compare and identify best practices, and formulate regional and international cooperation. Some CIS countries are also conducting studies on e-health. The presentation of the Department of Information Technology and Computing Systems of the Russian Academy of Sciences has prioritized the research activities in the field of medical informatics.

The Medical Informatics Research Center at the Institute of Software Systems of the Russian Academy of Sciences [75], the Institute of Modern Information Technology of the Federal Research Center for Informatics and Management [76], and the United Institute of the Problems of Informatics of the National Academy of Sciences of Belarus [77] are also conducting fundamental and applied studies in bioinformatics and medical informatics.

1.9. Terminological problems of e-medicine

The study of the terminological problems of e-medicine reveals that the term "telemedicine" started to be widely used and accepted in the mid-1990s. Later, the authors began to distinguish the terms "telemedicine", "e-medicine", "e-health", and "telehealth". At present, there is no definite approach to the scope of these terms offered by the researchers. However, the following views are available [78–82]:

1. E-health, including e-medicine (telemedicine) are broader terms. In this sense, the term e-health covers a variety of information and communication and medical services delivered remotely (mostly over the Internet).
2. E-medicine, telemedicine and e-health are different concepts. Thus, e-medicine covers medical services such as tele-recordiology, tele-radiology, tele-pathology, tele-ophthalmology, tele-dermatology, and tele-surgery. E-health also includes the use of ICT, medical communication services, picture archiving and communication systems (*PACS*), MIS, e-education, and electronic prescription of medicaments in healthcare.
3. Telemedicine (e-medicine) and telehealth (e-health) are the same concepts.

The American telemedicine agency has historically believed that telemedicine (e-medicine) and telehealth (e-health) are synonymous terms that cover a wide range of healthcare services. Providing the consultations to the patients via videoconference and various portals; remote diagnosis of essential functions; transmission and exchange of medical images, laboratory analysis, electronic data, reporting and accounting and management data, including continuous medical education; establishment and expansion of wireless communication taking into account the wishes and suggestions of the patient; and information support for medical research are considered as parts of e-medicine and e-health.

Evidently, the terms e-medicine and e-health were first used by ICT managers and marketers as the notions e-commerce, e-business, and e-solutions. At the same time, this term can be regarded as an attempt to advertise the new opportunities of the Internet in healthcare for the users.

Due to the lack of unambiguous approaches to "e-medicine", "telemedicine" and "e-health", today there is no a single definition. Thus, there are many definitions of these terms in literature.

In the academic environment, some researchers believe that the term e-health should remain in the business and marketing environment and should be avoided in scientific and medical literature. However, given the fact that this term has already included into scientific literature, a group of researchers has given the following definition in line with its scientific tradition:

e-Health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude and a commitment for networked, global thinking, to improve healthcare locally, regionally and worldwide by using information and communication technology [83].

In this chatper, the terms "e-medicine" and "e-health" are used as synonyms.

The analysis of the world practice on the development of e-medicine allows us to conclude the followings:

1. Formation of the national e-medical system envisages the identification of the legal status of electronic documents, protection and secure transmission of confidential information about the patient, scientific and technological and human resource training, compliance with international standards.
2. Most countries have adopted the development concept and national programs that set priorities of the informatization for the establishment of e-medicine system.

3. Informatization process has many scientific problems, most of which are of global character and require large-scale scientific research.
4. Currently there are no specific conceptual and strategic documents on the informatization of health in Azerbaijan.

Based on the above-mentioned conclusions, it is important to develop a state program that envisages the implementation of political, administrative, regulatory-legal, personnel, scientific-innovative and technological-software measures for the formation and development of e-health in Azerbaijan.

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CHAPTER 2. TELEMEDICINE

The development of high technology has affected all areas of human life, as well as the field of healthcare. Endoscopic surgeries using video and computer technologies, 3D scanning of internal organs during computer tomography and virtual examination of the patient are considered to be the most advanced areas of medicine and opens up a new era in healthcare. The application of new technologies requires new thinking which also requires completely new infrastructure, namely telemedicine [1, 2].

Telemedicine has been shaped due to the integration of computers and various telecommunication tools into medicine and their use in medical practice. Telemedicine has provided availability of high-quality economic medical care, and allowed to eliminate the geographical barriers in unfavorable areas, and increased access to health services. Telemedicine enables bilateral video conferencing, and transfer of X-rays and magnetic resonance images [3].

Telemedicine incorporates medical-preventive facilities, health research institutions and specialists in a single computer network. When faced with severe clinical situations, any physician can contact professionals at any point of the world. It should be noted that, besides its clinical significance, telemedicine is also economically efficient, i.e., it reduces travel costs, "ambulance" costs, the quantity of complications, and the duration of hospital stay. A new area of modern telemedicine called “Remote Control of Diagnostic and Surgical Instruments” is actively developing [4].

2.1. History of telemedicine

Although the term Telemedicine was first used by Kenned Berd, its history dates back to the earlier periods. The notion "tele" was first used by Einthoven in 1905. Einthoven was the creator of electrocardiogram. He transmitted electrocardiograms through the telephone network. As the distance between the stations was short, high quality transmission was not achieved. Later, in the 1950s, the concepts of "telegnosis" and "telepsychiatry" were proposed by Gershon-Conen J. and Cooley A.G. In the 1960s, the term telediagnostics was used to observe pathological states at a distance.

The term "teleconsultation" was first found in Cooley's studies in 1974. Various bioradiotelemetric instruments and systems were assembled to apply to various areas of medicine in the 1960–1970s [5].

The first intercontinental medical videoconference was held in 1965 where the cardiac surgeon Michael Debackey implemented an open heart surgery from another country. The intensive development of computer technology and telecommunications has enabled the development of new procedures and sessions of telemedicine. International doctors have set the goal of creating a network of telemedicine.

The most important development phase of telemedicine was the formation of mobile medical stations. This project was developed by *National Aeronautics and Space Administration* and called *"Space Technology Applied to Rural Papago Advanced Health Care"*. Due to this project, 4,000 people were provided with medical care [6]. At the end of 1980, the first military projects were implemented within the framework of telemedicine.

In 1993, telemedicine was registered as a separate international bibliographic area. In 1998, many European countries launched programs for *Advanced Informatics in Medicine (AIM)*. This program covers the scientific field of the European Commission, and its separate areas include the application of ICT in health and medicine.

In 2005, the WHO adopted historical document – *WHA 58.28 eHealth Resolution*. This resolution regulates the use of telemedicine.

2.2. The essence and tasks of telemedicine

There are many aspects of telecommunications related to health services. The term "telemedicine center" was first used and defined in 1972 by Kenned Berd as follows: "Telemedicine is a medical practice realized through the interactive audio and video communication systems without physical contact of physician and patient." The word "telemedicine" is derived from the combination of Greek words "tele" and "medicina", which mean "remote" and "treatment". Telemedicine has several definitions depending on the nature, fields and technology it uses [7].

Telemedicine is the provision of medical assistance to the patients through computers, the Internet and other communication technologies.

Telemedicine is referred to the use of telecommunication technologies to provide medical care and health information to consumers located far from health institutions.

Telemedicine is an integrated system that provides medical care using telecommunications and computer technology instead of direct contact between physicians and patients.

Telemedicine is the fastest way to provide health knowledge via telecommunications and information technology, regardless of where the patient is located and where the necessary information is needed [8].

Thus, telemedicine has no commonly adopted definition, though it has been defined by the American Telemedicine Association in more detailed form: "The objective of telemedicine is the transmission of medical data amongst remote institutions" [9]. Telemedicine assistance is defined by two indicators: 1) type of data sent (endoscopic drawings, X-ray images, results of laboratory analyses, etc.) 2) method of sending data (phone lines, satellite or cellular channels).

The infrastructure of telemedicine is composed of professional, information and educational resources, medical diagnostic devices, medical organizations with DB, as well as system users, communication channels and networking devices, and the measuring devices and other converters that transform medical data into digital electronic signals to be transmitted through communication channels.

Telemedicine tasks may include:

- delivering preventive services to the population;
- reducing health care prices;
- delivering services to isolated or remote users;
- increasing the level of medical care;
- monitoring the physiological parameters of patients;
- rehabilitation of patients requiring psychological and psychophysiological care;
- uninterruptedly providing educational process;
- providing the elderly people with quality medical care [10].

2.3. Main fields of telemedicine

Telemedicine technologies are applied in different areas of clinical medicine. The use of telemedicine in the practice of doctors enables the following opportunities.

Telemedical consultation is a widespread telemedicine service. This field of telemedicine transmits medical data through telecommunication channels. The subject of telemedical consultation includes the clinical status or clinical examination data of a patient. Telemedical consultation is based on point-to-point scheme. For example, contact between the patient's practitioner and the consultant.

Objectives of teleconsultation:

- specifying the diagnosis and treatment;
- checking the state of the patient by the physician after the treatment;
- obtaining the results of previous examinations;
- conducting initial consultation before the further consultation, treatment or operation.

Consultation can be realized online or offline. Online or synchronous consultation requires technical devices and is provided in real-time with the participation of the patient through video and audio broadcasting. Videoconferencing can be performed via digital telephone lines such as IP networks and ISDN [11].

The patients should be registered for online teleconference in advance. Offline or asynchronous teleconsultation is the easiest and cheapest way of consulting. This type of teleconsultation transmits electronic medical data and images from one user to another via emails. In this process, the data is sent to a doctor or specialist in advance and then diagnosis is appointed [12].

Teletraining includes performing video workshops, conferences and lectures using telecommunications facilities. Telemedical lecture is based on the multipoint-to-point scheme. During these lectures, the reporter interacts with the audience. Ultimately, these technologies create real opportunities for the uninterrupted training delivered by the physician without leaving the workplace. Thus, all participants can simultaneously communicate with each other. Teletraining provides the training of medical telemedicine training methods included in the training system of medical personnel [13].

Teletraining incorporates the followings:

- identification of medical commitments;
- specialization of doctors and nurses;
- realization of continuous training by telementors and teacher;
- working with graduate and doctoral students;
- conducting scientific-practical workshops on treatment-diagnostic methods [14].

Telesurgery is one of the key emerging trends. The main objective of this field is to remotely control medical equipment, research or surgical operations in an interactive mode. Since the application of this trend requires great responsibility, the reliability of the quality of telecommunication equipment has to be fully verified. Currently, numerous ICTs are already being used for remote surveys [15]. Telesurgery provides broadcasting during surgery and thereby:

- improves the quality of treatment and reduces the number of severe consequences, unsuccessful operations and doctors' faults;
- realizes medical consultation;
- delivers medical training to medical personnel.

Mobile telemedicine is one of the dynamically developing fields of e-health. Mobile telemedicine allows for performing home-based treatment and consultations on medical aid [16]. Mobile telemedicine provides wireless data transmission by incorporating numerous satellite connections. Data is transmitted to portable computerized devices. Mobile telemedicine acts as an assistant of doctors and rescuers, first aid staff and aviation personnel during technological or natural disasters.

One of the most important functions of mobile telemedicine is conducting remote telemonitoring. Remote telemonitoring system remotely performs registry of the physiological parameters of people suffering from one or more illnesses. This involves the control of the state of the people with chronic illness, the elderly and the workers in specific areas. One of the objectives of this system is to integrate sensors to the clothes, accessories and mobile phones. For example, a vest equipped with a set of cellular biosensors measuring heart rate, arterial pressure and other parameters, or mobile phones that record these parameters. These phones send the sensed data to the Health Center via GPRS (*General Packet Radio Service*), and assist people to determine their coordinates when they are in danger.

Patient is provided with medical assistance through home-based telemedicine. The patient's medical data is regularly sent to health professionals through the telemedicine devices sensing body temperature, blood pressure, electrocardiogram, partial pressure of oxygen and respiratory function. These devices may include chips, pendants or watches. The implementation of home-based telemedicine reduces the cost of patient's stay in hospital, and is intended especially for people with disabilities, and the elderly suffering from various chronic illnesses and those who need regular checkup [17].

2.4. Development of telemedicine

Norway is first country to practice telemedicine. The second project related to telemedicine was launched in France. The main objective of this project was to provide medical support to the marine and military forces. Currently, each Western European country launches telemedicine projects. At present, more than 250 telemedicine projects are implemented by the developed countries. These projects are grouped into clinical, scientific, informational and analytical types according to their nature, 48% of which is related to tele-education and tele-training, whereas 25% of them is managed through new data transmission channels and meets the needs of administration, and 23% is used to provide medical care to the population of remote regions without access to telemedicine. WHO develops a project for the creation of a global telecommunication network in medicine. The main objective is to share scientific documents and data, increase search speed and conduct video conferencing, partial discussion sessions and electronic voting. Developed countries use "Satellife" for the dissemination of medical knowledge and training and "Planet Heres" systems developed by WHO to coordinate global scientific telecommunication, international scientific expertise and programs. More than 70 international projects aimed at the purposeful development of various aspects of telemedicine have been funded and coordinated by the EU for several years. For example, "first aid" project - "*HECTOR*", home-based treatment project – "*HOMER-D*", and the project providing services for old people at home – *SWIFT*, etc. [18].

Leading IT-companies such as *Cisco* and *HP* are actively engaged in manufacturing the products to provide telemedicine services. *BBS Research* analysts report that funding of the telemedicine services in the global market increased from 1.6 billion in 2011 to $ 27.3 billion in 2016. Algorithms are developed and tested to compress the data based on these projects, and the automation of workplaces is carried out.

Large-scale research in the field of telemedicine is often implemented with the financial support of the government. Here are some of the studies in this field:

- remote monitoring of health indicators;
- researches in the field of operative care depending on the risk for patients' health;
- development of effective methods for the formulation and processing of medical data;
- development of models and algorithms for compression of medical images;
- development of distributed health database, taking into account the coordination issues with the international standards;
- creation of automated work places for various medical and diagnostic specialties (computer tomography, ultrasound diagnostics, radiology, biochemistry, etc.).

2.5. Telemedicine in CIS countries

Telemedicine is developing at high rate all over the world. More than 110 telemedicine centers are operating in Russia which host teleconference, teleconference and master classes each year. A number of professional public associations have been established in this regard: the Russian Telemedicine Association, the Association for Computer Technology in Medicine, the Association for the Development of Information Technology (IT) in Medicine, and others.

Relevant structures for telemedicine development have been established in Belarus, Ukraine, Uzbekistan and Moldova as well. Russia, Moldova, Kazakhstan and Uzbekistan are the leaders on the establishment and development of telemedicine systems in the CIS where sufficient funds have been allocated for telemedicine projects. Kazakhstan is launching a project for the creation and development of a telemedicine network covering more than 120 telemedicine centers. The implementation of telemedicine projects within the framework of the "Electronic Moldova" program is underway. “The concept of telemedicine development in 2000-2005" has been developed in Uzbekistan, and over 30 million dollars have been allocated for the establishment of a network of telemedicine centers. The state telemedicine program is being developed in Ukraine.

According to the decision of the CIS Regional Coordination Council, a regional telemedicine working group of the CIS countries is operating within the framework of the "Telemedicine and Electronic Health" interstate project. This group has developed a memorandum on the "Cooperation of CIS member states for the creation of appropriate national telemedicine-diagnostic systems". This memorandum was signed at the meeting of authorized representatives of CIS countries, including Azerbaijan, Chisinau, 2008.

The President of the Republic of Azerbaijan signed the Decree of the on the approval of the agreement dated April 11, 2014 on the "Cooperation of CIS member states for the creation of appropriate national telemedicine-diagnostic systems and their future development and use" and on the determination of competent authorities on this agreement.

2.6. Telemedicine problems

Telemedicine has a great potential to reduce uncertainty of diagnosis, as well as to advance the methods of clinical management, improve economic efficiency and the quality of treatment [19]. Despite this potential, achievements in the field of telemedicine vary in different countries and constantly face many challenges and obstacles [20]. Some of these problems are related to health records transmission and administrative costs reduction. Additionally, the following obstacles may hinder the development of telemedicine [21]:

- confidentiality and security issues;
- lack of common standards;
- interoperability between medical devices, video conferencing and other systems;
- telemedicine costs between doctors and insurance personnel;

- lack of knowledge of some patients and medical personnel in information and communication technology [22];
- linguistic and cultural diversity among healthcare providers and patients (especially low-income population) [23];
- legal problems;
- identification problems of medical specialists when using e-mail [24].

Technical problems that complicate the wide and fast introduction of telemedicine in healthcare are as follows:

- high rate development of ICT;
- complex technical infrastructure;
- diverse telemedicine technologies.

In order to avoid all these problems, global rules and standards have to be adopted in the field of telemedicine. The legal regulation of confidentiality, privacy, accountability and accessibility issues should be resolved [25].

At present, telemedicine is widely spread in the world. The development of telemedicine technology based on high standards is promising. Despite the varying levels of application of these new technologies in different countries of the world, their goals, objectives, negative and positive aspects are identical. Telemedicine technologies enable the removal of spatial barriers and create favorable condition for the expansion of therapeutic and diagnostic capacity of physicians, co-operation of medical organizations and the training of medical personnel.

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CHAPTER 3. DEVELOPMENT PROBLEMS AND PROSPECTS OF THE MEDICAL EXPERT SYSTEMS

Since the development of information technology, healthcare is one of its widely applied areas. It is known that doctors' performance is based on the synthesis of knowledge and experience of the previous generation of specialists. The rapid increase in knowledge, the improvement of the diagnostic methods and the trends toward narrow specialization observed in the modern healthcare in recent decades, make it difficult to make adequate decisions in terms of the abundance of information. Therefore, to ensure the adequacy of medical decisions made in various areas of medicine and to enhance their effectiveness, it is urgent to introduce modern mathematical methods and artificial intelligence technologies, as well as the innovative approaches. Using these tools, the introduction of developed intelligent ES in medicine ensures more effective results. The main advantage of these systems is that they include the professional knowledge and experience of specialists and experts, and assist and support physicians in making decisions about the diagnosis and treatment of certain diseases [1, 2].

3.1. Problems related to information abundance in medicine

The globalized world is completely believed to be the century of information; since 2012, 2.5 Exabyte (2.5 x1060 bytes) of information has been generated a day in the entire world which means the beginning of the century of "scary big data" [2–4]. Taking into account that medicine is a big area, which produces large amounts of data, according to the latest research, 30% of whole data collected and stored in the world is health data [4]. Moreover, by 2020, the medical data is forecasted to be 25000 petabytes [5], one can imagine how difficult it will be for doctors to make decisions in this information flood. Although information sources were previously few, now their number has extremely increased. Today, there are 100 thousand treatment methods in medicine, and treatment method is chosen on the basis of information received about the patient. Currently, the number of laboratory studies is increasing by geometric progression [6], whereas this figure in the past was 0.5 million a year and increased by 2 times every 4–5 years [7].

One of the problems arisen by the abundance of information in medicine is due to medical mistakes. It is indicated in [8] that the number of deaths due to doctors' mistake varies between 100 thousand (for comparison, it is like an airplane crash a day) in the USA where 15–18% of GDP is allocated to healthcare. While in Germany, this figure varies between30–60 thousand (in other words, imagine that a small town of Germany is sinking every year). Nevertheless, these mistakes are not intentional or because of the doctors' irresponsibility or non-professionalism. The main part of the doctors' mistakes is related to medicines which are wrongly appointed. Boston clinic reports that, today, there are more than 10 diseases and disease syndromes in the world, and more than 4 thousand medicines. There is a correlation between 2 thousand of them which limits the possibility of their combined use; furthermore, 300 different radiological procedures and 1100 laboratory analyses exist [9]. Therefore, the doctor "sinking" in this flow of information makes approximate decision about the patients choosing thousands of information, and the rest of the information are neglected by the doctor, because, of course, a human is not able to remember more than 7 indicators at the same time and put forward a judgment [10].

Of course, the impossibility of keeping in mind such a volume of information and the abundance of information in the process of diagnosis and treatment leads to the humanity problems. Taking into account the decisions made under time pressure at decisive moment, and the fact that any mistake may cost a human life (the patient's treatment is considered here), the importance of ensuring physicians with modern tools, which supports decision-making, can be comprehended. Depending on the nature of the issues to be decided in the medical sphere, medical information-retrieval systems, forecasting, information and surveillance, management, diagnostic, monitoring ES and others have been developed, without of which it is impossible to imagine modern medical systems. Each of these systems has its own appointment, certain structure, organizational and action principles, theoretical, algorithmic and instrumental base. Today, we should focus on ES in the field of healthcare, which are aimed at the diagnostics and treatment, monitoring issues and provide their successful solution.

This chapter focuses on the urgency of the establishment of ES, its state of the art, development trends, and the problems of knowledge engineering. It also analyzes the situation of establishing ES in Azerbaijan and puts forward proposals.

3.2. Technology for establishing ES

The term "Expert System" was first coined by Feigenbaum E. in 1977. Its essence is: "Involving expert knowledge of the principles and tools in the field of AI into the solution of practical issues which are difficult to be formalized" [11]. In other words, ES has the following characteristics, and therefore are subject to the resolution of issues that cannot be formalized:

- issues that cannot be expressed in numerical form;
- input data and knowledge about the subject area is ambiguous, imprecise and contradictory;
- purpose of issue can not be displayed with well-defined goal function;
- problem does not have an exact and clear algorithmic solution.

Dendral – the first ES was developed at late 1960s at Stanford University by Feigenbaum E. [12]. This system defined the organic structure of molecules on the basis of the spectrographic data of its chemical connections. Referring to the heuristic knowledge of expert chemists, who created knowledge base of ES, it was possible to find the decision right just with a couple of efforts out of million cases. The principles and ideas that form the basis of *Dendral* system were so effective that, even today, the chemical and pharmaceutical laboratories around the world are using them. The ideas and principles of the system realization are the basic principles of the recognition of images which is one of the main areas of AI.

Mycin ES was developed at Stanford University in mid 1970s, and decision-making problem was first solved on the basis of incomplete information [13]. This system uses the knowledge of medical experts for the diagnosis and treatment of meningitis and diseases of bacterial blood infections. The trials of the system, namely, the rules of the knowledge base were based on logical principles reflecting the specificity of the subject. The development method of *Mycin* ES is still being used as the basic principles of modern ES.

Successful results of *Dendral* and *Mycin* systems have stimulated the solution of difficultly formalized issues referred to expert knowledge with the use of all guidelines and tools in various spheres, consequently, the era of the development of ES aimed at addressing diagnosis, identification, management, forecasting, planning, monitoring, design and other issues has started. In general, the development criteria of ES in any field are defined by the followings:

1. Data and knowledge is valid and does not change over time;
2. The space of possible decisions is finite and not so wide;
3. Formal judgments are used in the problem solution;
4. To resolve the issue in accordance with their knowledge and shaping method, which is described in this knowledge will tell at least have to be an expert.

In most cases, the technology for ES establishment is called Knowledge Engineering. The experts, who set up this process, are called knowledge engineers, and they are closely interacting with one or few experts in specific subjects. A knowledge engineer acquires actual knowledge about the subject area and obtains the procedure, strategy and empirical rules needed to resolve the issue from the experts and establishes ES based on the gained knowledge (figure 3.1) [14].

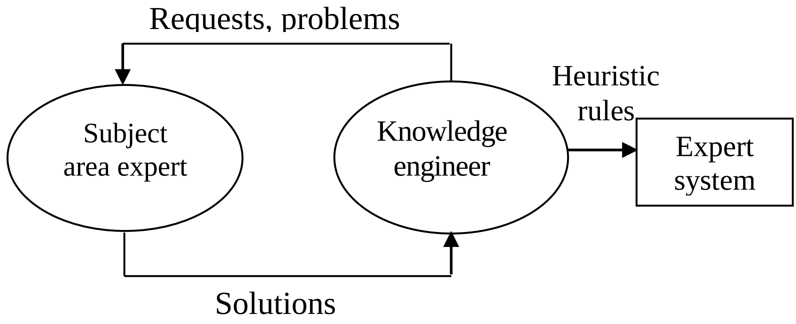

Figure 3.1. Acquisition of knowledge from the experts for the ES establishment

3.3. The issues of transforming natural medical intelligence into artificial medical intelligence

Methods of knowledge acquisition. As mentioned, one of the main problems of ES establishment is to obtain knowledge. The knowledge acquisition is the information as complete as possible obtained by the knowledge engineer for decision-making in the subject area. Subject area is an object studied for the automation and organization of the management. The strategy of knowledge acquisition is described in figure 3.2 [14]. This strategy uses automated and non-computer methods for knowledge acquisition [15–17].

Automated methods include Internet search engines (Google, Yahoo, Yandex, Rambler), Data Mining and OLAP systems that provide discovery and detection of the knowledge of practical significance out of original data important for decision-making in various spheres of human activity. The methods of knowledge acquisition without computer include *communication methods* and *text-logical methods*.

Communication methods refer to the methods of *round table* and *brain attack*. The round table discusses any problem with the participation of experts of the same rights. The participants first express their views, and then start the discussion. The participants prepare for the discussion in advance. Whereas, in brain attack, they do not prepare beforehand. The main goal of brain attack is the creation of ideas on the subject. After being generating a few ideas are analyzed and selected, and promising ones are developed.

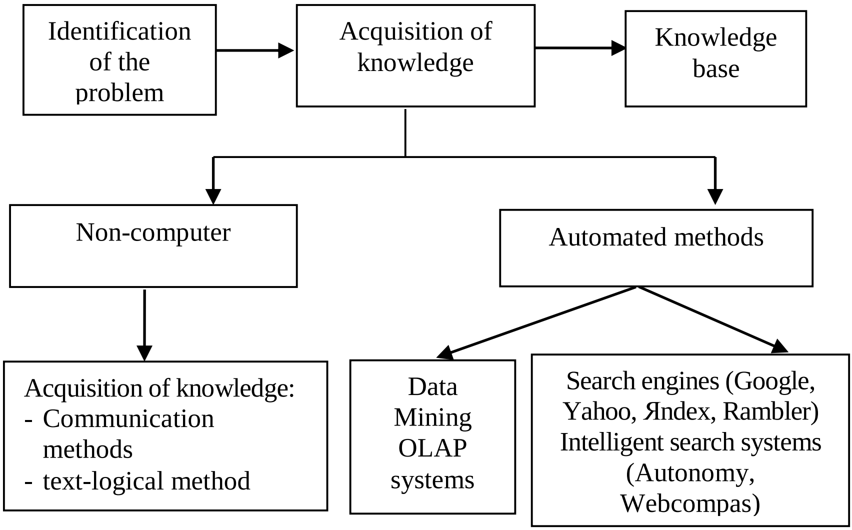

Figure 3.2. The strategy of knowledge acquisition

During the *interview*, which is one of the communication methods, the knowledge engineer prepares the questions in advance.

Unlike the *questionnaire*, during the interview, knowledge engineer may exclude or include some questions depending on the situation, and/or he/she can use different approaches to attract an expert and so on.

The *dialogue* does not include time limit and the questions are not prepared in advance.

The *game of roles* and the *game of experts* also refer to the communication methods. In the game of roles, the roles are distributed across the participants (experts). Then, they are given a certain event (situation) and the decision-making process is being observed. In the game of experts, a knowledge engineer watches the decision-making process in specific cases under the supervision of experts. Such games often use training simulators and computer systems.

Text-logical methods are associated with the analysis of regulatory and questionnaire materials related to the problem, orders, methodical manuals, instructions and other specific documents related to the subject. This method is based on the acquisition of the problem-related texts from the books, monographs, articles and other professional carriers of knowledge. The main highlights of understanding the text are: the formulation of the hypothesis about the entire text in advance (prior to experience); identification of the substance of unclear concepts (particular terminology); defining a common hypothesis about the content of the text (of knowledge); specification of the content of terms (from complete to sections); establishing internal communication between the separate key words and fragments; adjustment of the common hypothesis (correction from sections to complete); adoption of the main hypothesis.

Aspects of knowledge acquisition. There are three aspects of the acquisition of knowledge, namely, psychological, linguistic and gnoseological aspects [18, 19].

The psychological aspect is the key aspect that ensures successful and effective interaction between a knowledge engineer and a source of knowledge - an expert. Less loss of information during the conversation, and high level communication between an analytics and expert depends on the psychological knowledge. The process of knowledge acquisition during the communication can be described as the process of joint search for the truth. The communication model covers the participants, communication tools and communication object (knowledge). Depending on these components, three levels of psychological problem are: contact, procedures and cognitive. In the contact level, efficiency of the communication between the experts and analyst depends on their gender, personal temperament and the motivation of the communication participants. It is defined that better result is achieved if the experts and analysts are heterogeneous couple (male/female) and when the age relationship is as follows:

5 <(E_A – A_A) <20, (where E_A – expert's age, A_A – analyst's age)

Linguistic aspect. The main problem in the field of linguistic aspect is related to the concepts: general code, concepts' structure and user dictionaries. The general code is the intermediate communication language between a cognitologyst and expert. This language incorporates the scientific and special concepts of professional literature. This eliminates the language barrier between the cognitologyst and expert. Subsequently, the general code turns into the structure of concepts or semantic network which connects the concepts stored in the human memory. The user does not need to know the professional language in the subject area, so that the user dictionary is developed which is also worked out on the general code.

Gnoseological aspect. This aspect combines the problem of acquisition of new scientific knowledge, so that the process of cognition is often observed with the creation of new concepts and theory. The experts form of several laws basing on the empirical experience accumulated in the development of a knowledge base. Gnoseological chain can be expressed in the following sequence:

"fact – generalized fact – empirical regularity – theoretical law".

Cognitologyst is interested in empirical knowledge of the experts, and they cannot be agreed upon. Knowledge is characterized by the following aspects:

- systematicity (shows the location of new knowledge in multilevel structure);
- knowledge objectivity (it is practically impossible to determine);
- incomplete knowledge (impossibility of depicting the arbitrary subject field);

· knowledge historicity (associated with 95% growth or change in perceptions about the subject area over time).

At the initial stage, the cognitologyst uses decision structure and the various theories of experts to build a formal model of knowledge.

Description model of knowledge is to present the knowledge obtained from the experts in the form of certain rules. Description models of knowledge are re-classified in ES as follows [20–22]:

- Production model;
- Semantic network model;
- Frame model;
- Formal logic model;
- Relational model.

Production model is a rule-based model that describes the knowledge in the form of "If (condition), then (result)". "Condition" is such a sentence, on the base of which the search is enabled in the knowledge base, and the "result" are the situations obtained in the successful course of the search.

Semantic network model is an oriented graphics, and its hills express the concepts, while the definitions express the relations between the concepts. The concept Any object denotes any concept, and the relation – the links between the objects. This model was proposed by American psychologist Kuillian.

Relations in the semantic network include:

- "Part-full" type relationship (class-group, element-set);
- Functional contact ("occurs", "impact" and etc.);
- Quantitative relationship (more, less, equal, etc.);
- Spatial relationship (far, near, under, above, inside etc.);
- Attribute relationship (has features, has essence etc.);
- Logical relationships (and, or, no);
- Linguistic relationships and etc.

Frame model was proposed by Marvin Minsky in 1970 for the perception of the visual (spatial) view of knowledge. Frame is a unit of knowledge description, and its details may vary according to the current situation. Frame is the minimum possible description of any event, situation, process or object. The traditional structure of frame is as follows:

(**Frame** name:

(1st slot name: 1st slot essence)

(2nd slot name: 2nd slot essence)

(N-th slot name: n-th slot essence).

In the next step, each slot becomes the frame itself and derivates, so that this model is sometimes called tree model. For example, if we look at the room as a frame, its slots will be doors, windows, floor and ceiling. At the next stage, each slot can be viewed as the frame. In other words, if the frame is the door, its slots will be wood, iron, glass and etc.

Logical model of the description of knowledge is based on the formal logic and predicate logic and on the mechanism of logical conclusion of a human.

In the logical model of the descriptions of knowledge, the logical conclusion can be achieved based on 4 main formal logic:

1. *Modus Ponendo ponens*:
   If the implication $A \rightarrow B$ is true and A is true, then B is also true.
2. *Modus Tollendo Tollens:*
   If the implication $A \rightarrow B$ is true, B is wrong, then A is also wrong.
3. *Modus Ponendo Tollens*:
   If A is true and the conjunction $A \wedge B$ is wrong, then B is also wrong;
4. *Modus Tollendo Ponens*:
   If A is wrong and the disjunction $A \vee B$ is true, then B is also true.

Relational model of the knowledge description is built according to features, performance, characteristics, in a word, criteria of the object.

3.4. Modern medical ESs and their application trends

Today, ES is successfully implemented in medical field. There are thousands of ESs in different fields of medicine in the world [23, 24]. However, the acquisition of these systems is almost impossible, as they are very expensive. Let's review brief information about widely used ES below:

- ***WebMD Symptom Checker*** system. The patients can get detailed information by uploading into the system the symptoms associated with the diseases related to allergies, arthritis, cancer, colds, flu, cough, depression, diabetes, eye diseases, heart disease, skin problems, sleep disorders. The system even allows the patients printing a report for submission to the doctors (offering advice, diagnosis, treatment) [25].
- ***DXPlain*** is an example of intelligent clinical decision support system used to assist diagnostic process, and has a knowledge base that interconnects a list of diagnosis symptoms, laboratory data and procedures [26]. This is a software product of Massachusetts General Hospital.
- ***INTERNIST*** is a consultant system for the diagnostics of internal diseases [24]. INTERNIST-1 is a modified version of the system and widely applied today [27].
- ***CASNET*** is designed for glaucoma diagnosis and choice of treatment strategy. It is developed at Rutgers University in New Jersey, USA. It is based on the model of the semantic description of knowledge [24].
- ***EMYCIN*** is used for diagnosis and treatment of infectious diseases of blood, and it is an improved version of *Mycin* [24].
- ***Germwatcher*** ES is designed to detect, monitor and study the patients with infectious diseases in hospital; it was developed in 1993 at Washington University in St.Louis [28].
- ***PEIRS*** interprets and explains the reports on the chemical pathologies [29].

- ***HELP*** is a complete hospital information system based on artificial intelligence technology which supports not only standard functions of a hospital information system, but also decision support functions. *AppHelp* system offers automated judgments to take preventive measures during the acute pain in the abdominal cavity in the case of uncertainty. This system, developed for the diagnosis of acute pain in the abdominal cavity in 1972 at the University of Leeds (UK).
- ***PIP*** system developed at the Technical University of Massachusetts is a software product designed on the basis of information collected and generated associated with the kidney defects at Tufts-New Medical Center in England [24].

In general, at present, medical ES and decision support systems based on the methods and principles of AI technology are used in various fields of clinical healthcare. The ESs designed for clinical healthcare fields are applied in the following issues:

- **Providing alarms and reminders.** The ES designed for this purpose provides the real-time monitoring of the patients through bed-mounted monitor, i.e., tracks the basic parameters of the patient's condition after the operation. ES installed in the monitors evaluates the changes in the condition of patients and also reminds the importance or the rules of taking medicines (for example, sending reminders via e-mail).
- **Assisting the process of diagnosis**. Such ES assists and supports a doctor in complex situations to study the information about the patient and appoint diagnosis who does not have enough experience.
- **Search for the appropriate conditions (precedents).** This search can be conducted on the Internet or a local database. Such an intelligent system (agent) can choose appropriate knowledge about the main characteristics of the patient's condition.

- **Therapy control and planning**. This intelligent system is capable to control incompleteness, errors in the course of available treatment or the cases when insufficiently taking into account the specific characteristics of the patient.
- **Recognition and interpretation of images**. A large number of medical images are automatically interpreted: ranging from X-ray images to complex tomography images.
- **Monitoring clinical and pharmacological properties of drugs (toxicity).** The system is aimed at detecting side effects and inconsistencies of the drugs. It models clinical symptoms and the doses of taken drugs. The system fulfills the monitoring of the treatment process to control the use of drugs.

3.5. The development of medical ES in Azerbaijan

A number of ESs have been established in Azerbaijan in the field of medicine. Hence, in 1996, ES was established for the diagnosis of the acute surgical diseases of the members of abdominal cavity; ES was performed in clinical conditions and the development of knowledge base for the subject area [30]. The main objects and their characteristics of the subject field have been defined for the establishment of ES, diagnostic decision-making process has been analyzed, the main factors have been identified, the conceptual scheme of the subject field, and the structure of the database and knowledge base has been designed, the model for the solution of formal description of expert knowledge and diagnostic issues has been developed, ES's software has been developed and tested in real clinical hospital environment. The system is built with Lisp programming language.

Taking into account the mistakes made in the diagnosis of acute surgical diseases of the members of the abdominal cavity in the clinical medicine, ES with higher quality and faster diagnostic capabilities was created in 2000 [31]. In particular, the efforts were made to eliminate as much as possible the factors making impossible the clinical interpretation of health data and contributing to the wrong decisions, i.e. the lack health data bank about the patients.

In 2001, intelligent system executing primary diagnosis and hospitalization of the patients in multidisciplinary hospital was developed; and using artificial intelligence techniques the methodology of developing the intelligent system was proposed, which realizes primary diagnosis in the multidisciplinary medical centers and can allocate the patients within departments [32]. The software product of the system has been developed for the Emergency Department of Baku City Clinical Hospital No.1.

In 2003, the method for ES development were presented which examine the functional status of the thyroid gland and fulfills its functional diagnostics [33].

In 2004, the information and diagnostic system was developed for breast tumors, and differential diagnosis system - for breast tumors [34]. In the course of development, the following issues were solved: studying the computer system for the diagnosis of tumors of the mammary glands and research activities; examining a list of factors based on the opinions of a group of doctors and choosing the most important factors; initial data collection, storage and processing; generating numerical matrix - a diagnostic card for each type of tumor by the age groups; developing an heuristic differential diagnosis algorithm according to the diagnostic card and on the information about the specific patient; the differential diagnosis problem statement as a matter of classification and its interpretation in terms of the theory of neural networks; development, training and evaluation of two-leaved neural networks; comparative analysis of the results of the doctor's diagnoses and neural network; developing specific computer programs and information diagnostic system for mammary gland tumors.

In 2005, the intelligent system developed for the selection of the surgical intervention in orthopedics was first used for the creation of artificial vision of the source of pathology [35]. The snapshot generated through photo-robot allows studying the characteristics of the pathological source, their recognition and classification, and the visualization of consequences and results of the surgical operations. The signs and their frequency priorities have been first defined for the recognition of the pathological source; and the structural scheme defining the situations in accordance with the signs and identifying the treatment sequence through the surgical intervention was created. According to this scheme, ES has been developed for the knowledge base and automated recognition of its situations, as well as for the visualization of treatment methods.

[36] developed a software complex aimed at resolving the problems arisen from the examination of the ambulatory patients in the field of ophthalmology. The development of the system has resolved the following issues:

- ambulatory original data was collected for the diagnosis of eye diseases, and the database created based on it;
- knowledge base was developed based on the differential indicators and a number of health data in ophthalmology;
- dictionary block (Azerbaijani, Russian, Latin and English) of ophthalmic terms was built in the system;
- educational section was created in the system to contribute the students and doctors-interns which increases the effectiveness of the system;
- public service sector was created to educate and warn the population about the diseases.

500 patients with eye diseases were received by the ambulatory department ofeye diseases No4 of Baku City Clinical Hospital No1 were involved to the studies conducted for the implementation of this system.

[37] describes the software and structure of the virtual ophthalmologist ES in details.

[38] provides the establishment technology of ES for the diagnosis of neurological diseases, and the followings are implemented in the course of the system development: neurological diseases are investigated and the system of symptoms identified, including the methodology of knowledge description obtained for

the diagnosis of neurological diseases, the structure of the knowledge base, the mechanism of logical conclusion, fuzzy mathematical model providing diagnostic strategy, proper ES architecture, operating principles and instrumental tools have been developed. ES for the diagnosis of neurological diseases offers the knowledge description in 6 stages based on ontology [39]. Within the framework of the study, fuzzy logic and expert knowledge have been used to systematize the types of epilepsy, and a diagnostic ES is created [40]. The established system has been tested in clinical conditions and 83% accuracy is performed.

[41] presents the operating principle of the system created for predicting2 type diabetes in the people suffering from obesity. The system is developed on the basis of statistical data processing methods and uses dispersion analysis method for this purpose.

Today, the establishment of ES is one of the urgent issues. This urgency stems from the adoption of correct decisions for the improvement of services provided to patients, the appointment of diagnosis, and the selection of the treatment method. It is one of the fields of e-health formation. These systems are established by referencing to artificial intelligence methods and innovative approaches in the world of extremely growing information, and therefore, they require the adoption of appropriate technologies, and the training of the experts in the relevant field - knowledge engineers. This urges the training of specialized professionals in the integration of medical field and ICT once again and brings up benefiting from the experience of emerging countries in the field of e-medicine [42].

Citing the ES mentioned in this chapter, we can state that the Republic of Azerbaijan has successful achievements in the field of ES establishment, and intelligent ES developed for the diagnosis, monitoring and selection of treatment methods for various diseases are successfully tested in different health centers. However, such science-based systems established with innovative technologies are successfully tested, they are not exploited. Obviously, establishment of ES is often considered to be an experimental area, and it is related to constantly upgrading the systems to ensure the adequacy of the systems, inclusion of new knowledge, adding a new block, and this is regarded as a step forward perfecting the system. As a result, the creation of commercial ES can be achieved and the quality of medical services provided to the people can be improved with the mass use of the system. Failure of the established systems and enhancing the scale of the experiments to provide their realization prevents the contribution of these systems to the public.

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CHAPTER 4. THE INFORMATION SECURITY OF PERSONAL MEDICAL DATA IN AN ELECTRONIC ENVIRONMENT

Computerisation has penetrated almost all spheres of public life, including medicine. New conceptual approaches to the computerisation of medicine, which have included the introduction of EMR of patients, are the elements of healthcare modernization. The EMR system expands access to medical records (e.g., a patient's medical history and the results of a recent examination) and encompasses a shift to electronic document management and the integration of each person's medical data in the specialised data processing centres.

The development level of information technology, which defines the possibility of implementing PMD infrastructure, has contributed to the expansion of the followings:

a) availability of health services regardless of time and location of registered medical data;

b) technical possibilities for copying, reusing and disseminating information;

c) access to the tools of mass communication.

New opportunities have opened up for the development of telemedicine technology, which facilitates remote consultations, examinations and the processing of information in specialised centres, reducing examination times and improving diagnostic accuracy.

Behind these positive changes, the integration and prompt processing of PMD have been disrupted by hackers, creating a threat to the rights and legal interests of individuals. Therefore, the information security of personal data in electronic medicine (e-medicine) is quite relevant [1–3].

4.1. Safety and confidentiality of medical information: international experience

Problems with the privacy and security of medical data have always been important in terms of the development of the information society, and they have become even more pressing. The need to ensure the security of personal data has become an objective reality of our time that is particularly acute in medicine. International practice shows that the vulnerability of the privacy and security of PMD is the key obstacle in the effective development of e-health. Thus, healthcare organisations, which have access to personal data about individuals, are obliged to ensure the confidentiality and safety of all medical information. Any personal medical information, regardless of its medium, should be securely managed by the patients and the providers of professional medical services. Each party with access should be sure that the data has been handled only by the authorised persons. The typical MIS, which provides the establishment of a common information space in a medical institution, automates and optimises clinical processes and other aspects of the organisation from workflow to electronic medical history and clinical records, and provides information and intelligent support for the performance of all the services of the medical institution and managerial decision making. Being designed to support the performance of the medical institution, MIS differs from other software products primarily for that it stores and processes personal and confidential data. Legally, medical data refers to information that is confidential; access is restricted and regulated by the current legislation of each country. When establishing MIS, a number of measures should be implemented to ensure the safety of both the information and the information system as a whole, otherwise the use of MIS is inappropriate. Any user accessing MIS is fully responsible for ensuring the confidentiality of the information that she or he introduces, uses or disseminates to other users. Consequently, data security and confidentiality are key requirements for a modern MIS because its application in information, communication and computer systems can be problematic [4–7]. Confidentiality of PMD means that medical facilities accessing personal data are obligated to not disclose or disseminate personal data without the patient's approval. Legally, this requirement means that any healthcare worker accessing PMD must store such information and not disseminate it to third parties without the consent of its owner. In the context of e-health, data security refers to the status of the protection of individually identifiable medical information that is transmitted or maintained through electronic media or any other technical means of transmission and communication. Such protection encompasses internal or external threats; and protection of data from leakage, theft, loss, unauthorised termination, modification (falsification), duplication and blockage.

In the international practice, the information security of the e-health system shall provide the following:

1) confidentiality (medical confidentiality and protection of personal data), that is, protection from access by unauthorised users;

2) guarantee of the authenticity and comprehensiveness of the information during an exchange, and the protection of unauthorised modification of data;

3) availability, which is the access of authorised users to the information, and it is associated with the availability of a fault tolerance mode in MIS when the system is hacked or overloaded with requests [8–10]. The concept of the person-centred approach, which is the foremost in healthcare in the EU, US, Canada and Australia, is based on the principle of "the easier access to medical information, the better medical care will be". This principle involves the simplification of access to personal medical data of patients to provide qualified medical aid, and yet it presents serious challenges to the regime of information security in these countries, which is provided for by their regulations. According to the EU Data Protection Directive (1995), the EU member states have unified legislation throughout Europe, and today, many hospitals have the right to access personal medical data [11]. Information security support in information systems, including MIS, is established by the International Organisation for Standardization in the ISO 27001 framework which has been adopted in Azerbaijan as well [12].

Information security is guaranteed at the organisational (administrative and procedural) level through a security policy, wherein objectives have been formulated; at the procedural level through the development and implementation of a guide for staff and through physical protection measures; at the technical (hardware and software) level through the use of approved and certified solutions and a standard set of countermeasures: backups, anti-virus and password protection, firewalls, encryption, etc. To identify the sender (author) of e-document and to guarantee the absence of information distortion, an electronic signature is used that expires if the e-document is changed. As for data correction, as opposed to viewing, the requirements are even more stringent, and changes to the PMD cannot be made after a certain point. Corrections to a previously created document with an e-signature should be maintained, remaining inaccessible to medical workers when viewing PMD; in this way, an accountability mechanism is implemented, which is referred to as action logging and auditing [8–12].

The Health Insurance Portability and Accountability Act (HIPAA), adopted in 1996, is the US federal law that specifies the rules of confidentiality and the secure exchange of personal health information protecting it from unauthorised use. The law is applied to personal health information that is printed and stored electronically [13] HIPAA is based on two important ideas of patient care: privacy and confidentiality. Privacy concerns the patient's right to limit who is aware of her/his medical status, and what information should be available; and to be aware of who has access to the data and for what purpose (the transparency principle).

4.2. The specific features of personal medical data

The characteristics of security violations and the personnel, who will be processing the patient's information, should be considered while developing the security system for PMD and choosing the optimal information security mode for MIS. The analysis of the literature [14–17] reveals the following specifics of a patient's PMD:

1. The personal medical information of the patient is private (confidential) information, and the legal owner and a person in charge of the data is the latter, not a medical institution or medical

worker. This leads to a particular relationship between the patients as data subjects and the users of their personal information. Thus, it is necessary to protect their privacy, interests and confidentiality, along with the responsibility and interests of healthcare professionals and the legitimate interests of researchers and other third parties. PMD may contain confidential information, the contents of which include not only medical information, but also any other information obtained by the physician as a result of communication with the patient.

2. Time regulations for medical documentation, driven by the need for timely medical aid, are necessary. Delays in data availability for physicians may threaten the patient's health and sometimes even his/her life. Therefore, a reasonable compromise between the three components of information security, that is, confidentiality, integrity and availability of data, should be provided.

3. The patient's PMD is sent to various medical institutions which organises them into:

a) personal data which provides the unique identification of the patient;

b) type of medical data (information on the diagnosis, health status, recommendations and prescriptions, treatment, results of laboratory analyses and statistics;

c) storage location (registry, maternity hospital, ultrasound, laboratory, etc.);

d) medium (paper, video, electronic files);

e) authors of individual health information (doctors and hospitals of different fields, nurses and technicians).

4. PMD obtained in geographically dispersed and remote medical institutions is usually not stored in one place. This means that information about the medical services provided in one medical institution is not available in another automatically.

Confidential information is only the set of all or most of the distributed pieces of data, and some sections of medical data are not secrets. Therefore, to ensure information security, the management should restrict access while taking into account the multilevel roles, responsibilities, authority and priorities of health professionals, providing them with information in accordance with its purpose [18, 19]. Currently, this approach is used in the MIS of developed countries, ensuring access to certain elements of PMD for users in accordance with their authority.

4.3. Potential threats to the privacy and security of personal data in MIS

As shown in [2, 14, 17, 20–22], information security threats may occur when dealing with PMD. First and foremost are the threats to the privacy and security of information which can be grouped in two categories.

The first category is organisational threats that arise from the unauthorised access to patient data by an insider (medical worker) or an outsider (a hacker), and the threats due to the vulnerability of medical information systems. Organisational threats fall into five levels in increasing order of complexity:

1. Unintentional disclosure of personal information: the medical staff may unintentionally disclose the patient’s information to others via email and SMS sent to the wrong address or during data exchange.

2. Curiosity of an insider: medical personnel with the privileges to access a patient’s PMD can obtain information about a colleague’s illness out of curiosity, or to leak personal data of celebrities to the media, for example.

3. Disclosure of PMD confidentiality by the insider: medical staff with direct access to a patient’s PMD consciously steals the information for a profit, and in some cases, to cause moral or material damages to the patient, colleagues or others. The most common leaks occur to provide a list of patients to pharmaceutical companies for a substantial reward.

4. Violation of the integrity of PMD by an external agent through a physical intrusion into the institution where the PMD is stored: a hacker gains access to the information infrastructure of the organisation for data theft or its intentional failure.

5. Unauthorised access to the network infrastructure of MIS:

outsiders (former employees, patients, hackers, etc.) gain access to the network system of the organisation from outside to obtain patient data or to make the system inoperable, often for self-assertion. As of today, [23] the greatest threats to information privacy and security are caused by insiders; the attacker can be any member of the medical institution, from a nurse to the manager of the highest rank.

The second category is technical (system and physical) threats that arise due to irregularities in the chain of information flow as a result of unauthorised or accidental access to the database, unauthorised distortion, data destruction, destruction of the hardware, equipment failures, file deletion or damaged data, the unintended consequences of remote backup and unauthorised modification (falsification) of data, etc.

Since the concept of an information system is particular to a situation, healthcare institutions have developed guidelines and documents defining the general and private threats of a typical MIS and appropriate protective measures for processing PMD.

International experience shows that the greatest threat to the privacy in the infrastructure of e-health records is associated with the reuse of PMD. This concerns cases in which the information to be disclosed for a specific purpose may be used for other purposes as a result of authorisation [17].

Medical organisations generate and store vast amounts of data, and turning big data into the most important practical information is a difficult task. Yet, processing this unstructured information could offer unique knowledge [20]. Thus, PMD plays an important role in clinical, epidemiological, environmental and other scientific studies to develop new treatments for various diseases, to collect and analyse statistics, test the pharmacological effects of new drugs, improve healthcare quality and predict the potential outbreak of various diseases. Nevertheless, the disclosure of health information to researchers raises concerns about privacy violations. The terms defined in legal acts such as HIPAA allow healthcare organisations to disclose medical information to researchers only if they have the patient’s consent, or in exceptional cases, as outlined in HIPAA, depersonalisation of personal data is required for the use of health information. The regulation of access to health information includes public and private hospitals, insurance companies, administrators, physicians, pharmacies, employers, educational institutions, research institutions, data centres, organisations for accreditation and standardisation, laboratories, pharmaceutical companies and financial agents. Another third party interested in the patient's information includes relatives, healthcare workers, and marketing experts, representatives of various public assistance programs, credit bureaus and law enforcement agencies. In short, many individuals are interested in the acquisition of impersonal PMD. However, with all the good intentions regarding the future use of anonymous PMD, there is a possibility of information abuse. The availability of online public information through social networks and data obtained from pharmaceutical companies and other sources reveals the material conditions and health conditions of the patient. The pharmaceutical companies and insurance agencies may manipulate the acquired information. In addition, there is a theoretical threat of "de-anonymisation" of the e-health record compared to the data from different sources. Sales of medical information have occurred in a separate segment of the black market, and the confidential information trade has a high-yield. Every year, millions of records of the patients' personal data are leaked from the medical data centres of developed countries, and clinics lose billions of dollars due to this. The larger and more deeply embedded the electronic information system, the greater the leakage of illegitimate content. Statistical data on the US healthcare market shows that the most common source of leaks is theft: data loss occurs in 45.2% of cases, and in most cases, the perpetrators are medical personnel of various ranks who have a direct access to the data [24]. In 22.1% of cases, data loss occurs as a result of unauthorised access to the information, in 9.5%, it is a result of lost media, in 6.1% cases, it is due to a hacker attack, and in 4.0%, it is due to the absence of a password on an electronic device. The common violations of the security of PMD are the following:

1) data leakage and theft, that is, breach of confidentiality (a full breach when an attacker accesses the database, or a partial breach when an attacker acquires unauthorised access to the information);

2) data loss due to unauthorised data termination, deletion when accessing the data directly or through the system; PMD loss (information on drug reactions, allergies, previous diseases, the results of laboratory tests, therapies, etc.), which may cause time to be wasted on information recovery, perhaps jeopardising a human life;

3) accidental or intentional distortion or unauthorised modification (falsification) of the data through the system; or direct access to the database, leading to erroneous medical information that in turn causes incorrect medical decision making, endangering human life and health.

The violation of the security of PMD may have

– quite serious moral, physical and material consequences, affecting privacy;
– personal health and safety; financial and commercial confidentiality;
– unjustified discrimination by employers and insurance companies;
– obstacles to political or career growth, and so on.

4.4. Personal data protection

The information security of PMD in e-medicine is provided for by the coordinated and integrated use of an appropriate legal framework, organisational measurements, safety software and hardware devices. The moral and ethical aspects of the disclosure of PMD, legislative responsibility for privacy violations and the damage caused to the citizen should be taken into account [25].

Figure 4.1 shows the classification of the measures of PMD protection.

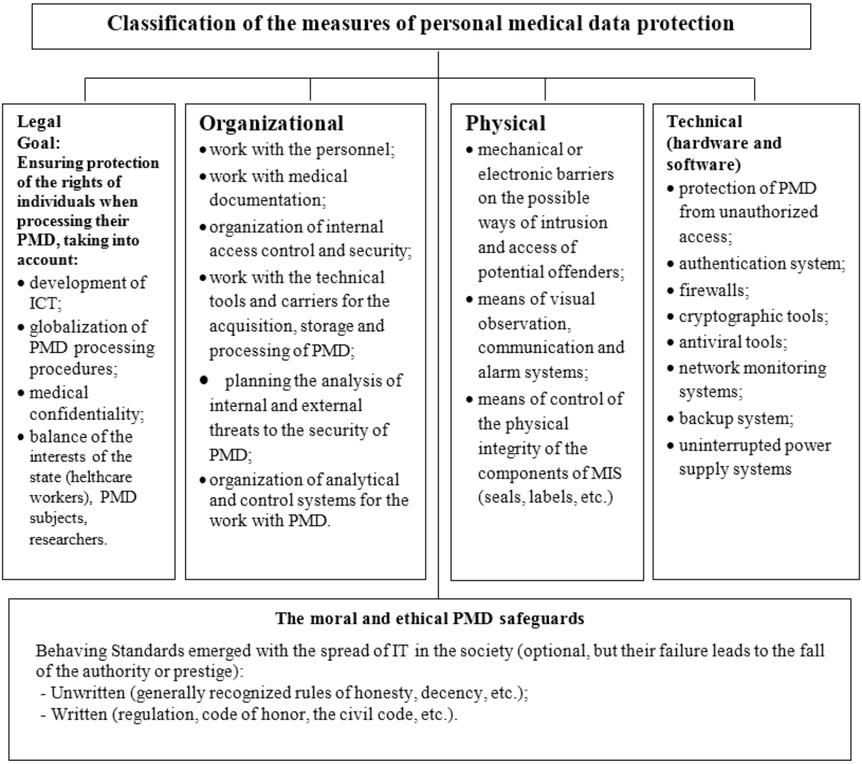

Figure 4.1. Classification of the measures of protection of personal health information

An electronic signature is used to authenticate the electronic document sender (author) and to protect the content of the document (without distortion of information). It will be invalid if the changes are made to the electronic document. Unlike the review of the data, the requirements for their correction are stricter, and the adjustments are made after the patient's EHR is completed. Otherwise, when the texts previously created and signed by the electronic signature tools are modified, the previous texts should be subsequently kept unaccessible to MI employees who are reviewing the EHR. In other words, reporting mechanism including protocol-recoding and audit should be implemented [8–12].

Although in various regulations of the developed countries (the US, Canada, Australia, and the EU) the responsibilities of data centre operators for the dissemination of personal data are specified, and the penalties of fines are fixed, these measures have not yet prevented leaks of confidential information. There are at least two reasons for the growing number of leaks: the imperfection of medical information systems and the weakness of the legal framework [24, 26, 27].

4.5. The legal framework for the protection of personal health information in Azerbaijan

Over the past two decades, the process of informatisation in Azerbaijan has intensified, and the country has made great strides towards the establishment of an information society. Despite this, healthcare remains one of the least informatised sectors of the national economy in terms of the level of digitalisation, and the development of MIS in this area is still at an initial stage [28–30]. Nevertheless, the problems of storage and transmission of medical data, protecting the patient's electronic data in governmental agencies and private medical institutions and ensuring the confidentiality of patients' medical information and the activities of medical institutions are being addressed by the authorities, researchers and developers. Currently, information security of personal health information in Azerbaijan is regulated mainly by the following political documents:

1. Universal Declaration of Human Rights, the United Nations (UN), 10 December 1948;
2. Convention on Protection of Individuals with regard to Automatic Processing of Personal Data, Council of Europe, January 28, 1981;
3. Constitution of the Republic of Azerbaijan, August 3, 2003:
4. Law of the Republic of Azerbaijan on Personal Data, May 11, 2010:

5. Law of the Republic of Azerbaijan on Health Protection, 25 June 1997:
6. Law of the Republic of Azerbaijan on Information, Informatization and Protection of Information, 3 April 1998:
7. Law of the Republic of Azerbaijan on Electronic Signature and Electronic Document, March 9, 2004.

The Article 12 of the Universal Declaration of Human Rights [31] states "No one shall be subjected to arbitrary interference with his privacy, family, home correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks." Considering the importance and value of information about a person and respecting the rights of the citizens requires the government to mandate that organisations and individuals safeguard the reliable protection of personal data. For example, the Council of Europe adopted the Convention on Protection of Individuals with regard to Automatic Processing of Personal Data [32] in 1981, ratified by the members of the Council and open for adoption by non-member countries. The Convention, ratified in 2009 by the Milli Majlis (Parliament) of Azerbaijan, was enacted in September 2010, obliging the Republic of Azerbaijan to adopt the activities to protect personal data subject to the European legislation. The Law on Personal Data [33] was adopted in May 2010 in Azerbaijan which regulates the acquisition, processing and protection of personal data; the development of a personal database in the national information medium; and the issues related to the cross-border transfer of personal data, specifying the rights and obligations of existing state agencies and local authorities, individuals and legal entities.

Article 32 (Personal Inviolability) of the Constitution of the Republic of Azerbaijan [34] states "Everybody shall have the right to preserve personal and family secrets", and Article 41 (Right to Health Protection) declares that persons of authority shall be made responsible for concealing facts that create danger to a person's life and health.

Protection of confidential information is one of the most pressing problems to be solved in medical institution that are digitalising healthcare systems. The Law of the Republic of Azerbaijan on Information, Informatisation and Protection of Information considers documented information to be confidential, the access to which is limited in accordance with the legislation of the Republic of Azerbaijan and is not transferable to third parties without the consent of its owner [35]. The use of e-signatures in accordance with the Law of the Republic of Azerbaijan on Electronic Signature and Electronic Documents [36] improves the confidentiality of the exchange of health information, and promises the authenticity of the content of electronic documents, which expire when amendments are made. The law of the Republic of Azerbaijan on Personal Data considers personal data as any information that directly or indirectly indicates the identity of a person. This law requires all institutions to fulfil the necessary requirements for the processing and protection of personal data. The Law on Personal Data is also applied to medical institutions of the Republic of Azerbaijan, where general personal data (name, passport number, address, etc.) and special categories of personal data such as information about the health status of patients are processed. Medical data becomes known to the medical institution when providing medical services. However, since health issues and the patients' rights, including the right to medical secrecy, its protection and liability for its disclosure are governed by the law of the Republic of Azerbaijan on the protection of public health [37], as interpreted based on the Law of Personal Data, PMD causes certain misunderstandings and disagreements. In accordance with the law of the Republic of Azerbaijan on the protection of public health, information containing medical data is defined as an "official" secret and "personal data"; that is, any information about the facts, events and circumstances of one's private life and personal or family secrets that could enable identification of the person.

In Article 53 of the law on the protection of public health, medical secrecy is:

1) information about healthcare claimed by the citizen;

2) diagnosis of the illness;

3) health condition;

4) other information obtained during the examination and treatment.

The information to be kept secret and the responsibility for its disclosure is legally guaranteed. The same article states that confidential medical information may be transferred to other citizens, researchers interested in information on the examination and treatment of the patient for scientific research and scientific or educational publications only with the consent of the citizen or his/her legal representative. However, in some cases, according to the public interest and requirements specified in Article 53 of the law, the physician is free from the obligation to comply with medical confidentiality. The physician is obliged to report infectious diseases and the risk of their spread, mass poisoning, suspected illegal activities and harming to the health of citizens. In accordance with Article 52 of the Law of the Republic of Azerbaijan on the protection of public health, the physicians who violate the Hippocratic Oath, reflecting the moral and ethical aspects of medical practice for many centuries (since the third century BC), have a legal responsibility.

4.6. Prospects for the development of information security of personal medical information

Today, the medical system in CIS member countries, including Azerbaijan, is within the scope of the general legal framework in the field of information security of personal data, and thus, institutions must ensure the protection of the rights of citizens when processing their data, including the protection of rights to privacy, personal and family secrets. The experts have focussed on specific sectors in which the development of a separate regulatory framework similar to those in a number of sectors (e.g., banking) seems to be appropriate. The lack of a regulatory framework that governs the protection procedure and security of information in the medical sector in the CIS countries often causes inadequate decision-making.

In practice, there are many conflicting situations, the legislative resolution of which is not available today [38–41]. For example, there is a very real threat that an employee of a medical institution who was fired could access a customer database. However, the current legislation does not specify the protection of PMD from data leaks even with a full set of documents regulating the PMD processing. Furthermore, most personal data of the patients processed in MIS is referred to as a "special category of personal data" (health information, laboratory tests, etc.), but in other cases, the category of "biometric personal data" is specified which enhances the system security requirements [42].

The safe cross-border transfer of patients' personal data can be provided by medical institutions during telemedicine. Personal information should be protected, but some data is required to be disclosed (published). According to the legislation, medical personnel are responsible for confidentiality, but the written consent of the patient is required for the processing of the patients' PMD by non-medical professionals who are not obliged to keep medical secrets. In addition to the medical staff of an institution, there are workers performing other professional functions. For example, the performance of any MIS relies on administrators (of the system, database applications, etc.), who are not medical professionals, although they have access to the information.

The rapid introduction of the Internet of Things in medicine should also be noted. Today, most people use networked portable devices to monitor health, control nutrition, perform exercises and track vital signs. Physicians are able to rapidly and accurately adjust and optimise implantable devices such as pacemakers, often without resorting to invasive procedures [43]. However, along with the advantage of the introduction of network technologies in the medicine, the risks of confidential information about the personality and health of the patient are growing, as medical information is considered especially valuable among hackers. International practice shows that, although legal documents in the field of personal data offer a flexible tool for effective protection from possible security threats, there is a need to develop additional recommendations with document templates and typical threat models for the typical MIS of medical institutions [44-46]. The US, the UK and some other countries have a separate legislative framework governing the issues of information security of personal health information, including medical and health secrets [12, 13, 47]. Thus, there is a need to develop internal regulations and frameworks that can clarify for medical institution employees how to act in terms of informatisation of medicine. Subsequently, a typical threat model must be developed, according to which the measures should be taken for the protection of confidential information, and the level of PMD security should be defined.

At the same time, when selecting the level of protection for a certain MIS, the following items should be taken into account:

1) type of personal data;

2) number of subjects, the details of which are stored in MIS;

3) status of the medical institutions (e.g., potential threats in a small medical institution may not pose a great danger);

4) relevance of threats, depending on the vulnerabilities in the system software, applied software. All of these factors constitute a particular way of applying PMD protection.

Considering the global experience in the development of specific legal acts regulating the information security of personal health information, the Ministry of Healthcare in Azerbaijan should develop legal and methodological documents regulating MIS implementation in medical institutions, the relationship between personal data and medical information, and the protection and security of medical information. This will enhance the awareness of the managers of medical institutions, medical personnel and other interested parties of the protection of patients' personal information. With the development of e-health, the widespread introduction of computer processing technology of PMD, cross-border exchange of information, and the development of MIS, a comprehensive and innovative approach is required for the development of legal, organisational and technological safeguards to preserve health information, including medical data, from unauthorised access. This requires taking into account the features of the actual situation in the field of PMD.

So, first of all, we should take into account the fact that information security of PMD is not one-time process, but continuous [48]. It means that an information security system must be constantly updated, taking into account the specific characteristics and dynamics of MIS, the increased technical capabilities of intruders to copy and disseminate information, the efficient solution of the safe data transfer problem, the resources, the typical threat model, and the protection level of PMD in a particular organisation, and so on.

Many medical institutions neglect the protection of PMD; the resources allocated for the protection of e-databases of the patients' HER are insufficient or there is a lack of qualified staff members who are competent in the technical protection of information and familiar with the relevant legislation [40]. One of the most effective approaches in this situation may be the development of decision support systems (DSS) to generate recommendations to support the authorised persons in decision making with respect to the information security of PMD in medical institutions through the knowledge of highly qualified experts. DSS ensures the identification and formalisation of decision making in the design process of PMD security systems, including the identification and assessment of potential threats to the information security of each medical institution, and the corresponding measures to protect PMD, eliminate threats and determine the information security level required for its regular functioning [49–51].

The study leads to the following conclusions:

1. Due to the development of e-health, the widespread introduction of computer technology for PMD processing and cross-border data exchange, the development of health information systems requires an integrated, innovative approach to the development of legal, organisational and technological safeguards to protect health information, including medical data, from

unauthorised access.

2. The problem of personal data protection in medical institutions has its own particularities; according to which separate legislation has been developed in countries with advanced e-health systems. This legislation regulates the issues of the information security of personal health information, confidentiality and privacy, access to personal data and responsibility for its use.

3. There are normative and methodological documents that regulate the activities, rights and duties of personnel in the medical institutions of Azerbaijan in terms of e-health, and define the protection and security of medical data and PMD during internal and international data exchange.

4. The development of new conceptual approaches is required to support decision making by the authorised persons to ensure the information security of personal health data in medical institutions.

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CHAPTER 5. BIG DATA IN ELECTRONIC MEDICINE: OPPORTUNITIES, CHALLENGES AND PERSPECTIVES

With the emergence and rapid development of information and communication and network technology, the world is confronted with an avalanche increase of the information received in a society called the "information explosion" [1, 2]. The volume of generated information is growing exponentially, and today, approximately 90% of the data in the world has been created in the last two years [3]. In accordance with a new study Digital Universe, conducted by the research firm International Data Corporation (IDC) [4], by the next 8 years, the volume of data throughout the world is predicted to reach 40 zettabytes. This means that 5,200 gigabytes of data will be accounted for each person on the Earth. At the same time, IDC estimates that today less than 1% out of all available information has been analyzed, and at least, 20% has been protected.

Unprecedented growth of information, only a tiny part of which is used worldwide, demonstrates an understanding of the indisputable fact that the effective use of the increasing amount of information should be one of the greatest scientific and technical challenges of the XXI century [5].

Medicine is one of the industries that historically has been generating a large amount of data, traditionally managed by accounting, compliance with regulatory requirements and criteria for the quality of services delivered to the patients [6]. At the same time, medicine belongs to the category of spheres of activity, which most lagging on a number of client-oriented industries (banking, retail, etc.) for the use of IT and, accordingly, Big Data. For the first time, medicine information technology was applied in the 60's of the previous century to collect and process large amounts of different statistics. However, the amount of medical data has been significantly increased only during the last 15-20 years, due to the transition to digital format. Despite storing a large part of the medical data in paper form, the tendency of rapid digitization has facilitated the accumulation of terabytes of data [5]. According to some estimations, the volume of medical data in 2012 reached about 500 petabytes [7]. Recent studies show that more than 30% of all data stored in the world is represented by medical information, and in the future, this share is expected to rapidly increase [8]. According to forecasts, by 2020, the amount of medical data will reach 25,000 petabytes [9].

Huge streams of medical data provide great opportunities for the development of methods and applications for expanded analysis of the latter. Indeed, the real value of this stream can only be understood in the case of promoting the information extracted from the data to improve the quality of medical services [10, 11].

This chapter aims at studying the potential of Big Data phenomenon in medicine as the means of improving the quality of the healthcare services through the possibilities of analytical support of medical and diagnostic, organizational and administrative decisions.

5.1. Key elements that define the information explosion in medicine

According to [12] medical data is mainly generated due to the following three key elements: a set of personal EHR, biotechnology, which laid the foundation for personalized medicine, and research and development (R&D). This list is supplemented by two more indisputable key elements that ensure the generation and rapid growth of information which includes advanced ICT and the Internet.

EHR integrates electronic personal health records related to one person, collected and used by several health organizations [13]. In the Russian literature, an analogue of EHR is an integrated electronic card of patient (IECP) [14]. In fact, IECP consolidates personal medical records of the patient accumulated in EHC of separate healthcare organizations. The term EHC is an analogue of the international term EMR, and it is an electronic version of the patient's history.

Biotechnology, which caused a boom in molecular medicine, has stimulated the rapid growth of the volume of data, in particular personal genome, in biology and medicine. Further development of the science and technology has led to exponential decrease in the cost of genome-wide analysis, and has contributed to the explosive growth of data specific to a particular individual. Therefore, in 2012. the cost of decoding the human genome sequence fell below 1000 dollars, whereas in 2003, this figure was about 40 million dollars. As a result, this procedure became available to the masses [15]. Since the failure of gene structure is one of the causes of any disease, the gene therapy can enhance the effectiveness of the prescribed treatment by reducing the negative effects on the body. With the help of Big Data technologies, human genetic code can be compared to other medical conditions, and it is possible to exactly find out how their genes correlate with diseases. The study of the genetic characteristics of an individual is one of the fundamental elements of personalized medicine, the main purpose of which is the providing a certain drug to a particular patient in appropriate doses and at a particular time [16, 17].

Big Data Sources also include other biometric data, such as scanned fingerprints, handwriting, retina, X-ray and other medical images, and the values of vital signs (blood pressure, pulse, etc.).

R&D. Medicine refers to one of those areas where a rapid development of science and technology is observed, and the results of scientific discoveries and developments are manifested quite clearly. The world is now facing a new challenge as an exponential growth rate of medical knowledge discoveries. Today, available biomedical literature catalogs include more than 18 million articles, with more than 800 thousand of them were cataloged in 2008. The rate of replenishment of medical literature doubles every 20 years, and since 2012, the number of annual revenues has exceeded 1 million [18].

An analysis of the dynamics of past 150 years, during which the effects of industrialization and information explosion manifested most acutely, shows that a typical doctor of general aid should be aware of about 10 thousand of diseases and syndromes, 4 thousand drugs, among which there are more than 2 thousand interactions, which define the possibility of sharing, and 1,1 thousands of laboratory tests [19].

Processing technology of large data can assist in the systematic analysis of unlimited volumes of multi-type medical information.

ICT and the Internet. Uninterruptedly growing rate of introduction of ICT in medicine does not only give a powerful impetus for change in this area, but also becomes the key tools in its transformation. This is accompanied by the rapid development of ICT itself. On the one hand, followed by the emergence of new platforms, hardware and software, network technology, models of data acquisition, storage, processing and analysis, on the one hand, emerging new sources of information generation.

Certainly, the Internet is an important source of health information, providing people with previously unavailable possibility of acquiring knowledge about diseases and medicines, diagnosis clarifying, the search as an effective treatment and as a physician of certain specialty, etc. According to the survey carried out in 2010 by the international consulting and marketing agency Manhattan Research LLC, the half of the patient-respondents surveyed the use of the Internet to search for medical information on health, diseases and their prevention, medicines, and etc. [20]. At the same time, 9 out of 10 patients make decision on their own treatment, based on data from the network. At once, the Internet plays a role of basic infrastructure in the generating processes, and in a reliable and secure transmission of medical information.

According to Cisco, in 2012, third of 2.8 zettabyte of transmitted information was accounted for the data automatically generated by the equipment and devices connected to the Internet or to the Internet of things. Cisco IBSG forecasts that, by 2020 50 billion devices will be connected to the Internet, despite the fact that these prognoses do not take into account the rapid development of the Internet technology and devices [21]. Besides the development of the Internet of Things and its further evolution, namely the Internet of Everything, which enables machine-to-machine (M2M), there is another powerful source of data generation [22]. This is an availability of networked portable devices (remote sensors and sensors of physical activity, diagnostic tools of public use, and etc.) [23], monitoring the status of patients' health. Adjustable electronic sensors produce millions of transactions per second, and therefore, reliable solution that can convert, save and work in real time is required. Certainly, it is possible with big data technologies.

The rapid development of mobile wireless communication and applications has stimulated the development and distribution of the methods of their innovative application to address the priorities of medicine and healthcare. This has led to the formation of a new field of e-health, known as Mobile Health (mHealth) [24]. According to the International Telecommunication Union (ITU), today, the number of wireless subscribers is reaching 5 billion people in the world, and over 85% of the world's population is in the coverage of commercial wireless network signal [25]. A large part of the data produced in the period from 2012 to 2020, will not be generated by people, but by various types of devices in the course of their interaction with one another and with data network (sensors, smart phones, RFID, satellite navigation systems etc.) [26].

5.2. Definition and essence of the concept of "Big Data" in medicine

Before turning to the study of the concept of Big Data in the context of e-health, the definition of the term should be explained.

Analysis of the literature shows that, today, the term Big Data has no strict and universally accepted definition. According to [27], Big Data is the set of so voluminous and complex data sets handling of which with traditional tools in a reasonable time is quite difficult. McKinsey Institute [5] reports that the term Big Data means a set of data a size of which is beyond the capabilities of typical database for the collection, storage, management and analysis. Currently large-scaled data is considered a volume of which reaches 1terabyte (1 terabyte = 1024 gigabytes) or more. Big Data is usually measured with the terms as "terabytes, petabytes, exabytes, etc." (1exabyte = 1 billion gigabytes). The report submitted in August 2012 in the US Congress, proposed the following definition: Big Data is the large volumes of data of high velocity, complex, and variable data that require advanced techniques and technologies to enable the capture, storage, distribution, management and analysis of the information" [11]. Another definition of the term is given in [28]: “Big Data – is a collection of tools and methods for processing the structured and unstructured data, huge amounts of different sources subjected to constant updates, in order to improve the quality of decision-making management, and to create new products and improve the competitiveness."

Stating from the above-mentioned definitions, the essence of Big Data is to enable high-velocity analysis of large volume of diverse data rapidly updated through new methods and technologies of data processing in real time. Big Data processing aims to identify the relationship between all the unrelated data and the identification of new hidden knowledge needed to support decision-making, to create new products, to improve the competitiveness of enterprises, etc.

Let’s revise the definition, specificity and the nature of Big Data concept in the context of e-health. To do this, first of all, the term "e-health" and "e-medicine" should be explained, the interpretation of which has multiple approaches [29, 30], and the author's understanding on these concepts should be clarified.

Accordingly, by definition, healthcare is a branch of state authority aimed to organize and provide affordable health care for the population, and to preserve and improve health rate [31]. In other words, the basic functions of the industry are the institutional (administrative) and managerial functions oriented at data analysis, forecasting and effective planning of the future development based on representative statistical samples, time series, and so on.

Medicine is a system of scientific knowledge and practices, united in order to define, treat and prevent disease, and to preserve and promote the health and ability of people prolong their lives

[31]. Medicine, as a science of healing, encompasses a gigantic system of ever-increasing knowledge and data, the volume of which makes it difficult to work with them. Therefore, the use of modern technologies for processing the medical knowledge and data, which provide the opportunity to support therapeutic and diagnostic decisions, is vital for medical institutions. The main priority of the digitization should be the task of medical support activities that directly determines the quality of medical services, but not taking into account the problem of statistical indicators [32]. Based on the objectives of medicine and agreeing with those authors, who believe that informatization should aim to support medical and diagnostic solutions, and information is important for doctors first of all for the treatment of the patient, rather than including it into the accounting system, this paper prefers the term "e-health". Therefore, this paper discusses the phenomenon of Big Data in electronic (digital) medicine, considering this term in a broader sense, including organizational and managerial processes of the healthcare of the population.

By definition, Big Data in medicine - is rapidly rechargeable various electronic medical data of a colossal volume that cannot be managed by traditional tools and methods, software and/or hardware [33].

5.3. Key indicators of Big Data in medicine

The most common disclosure of the phenomenon of Big Data is by specifying the problems encountered at the present stage of technological development in data processing [34, 35]. The main problems pertained to Big Data include Volume, Variety and Velocity. For some areas of activity, including medicine, researchers and practitioners introduced two more characteristics: Veracity and Value of Big Data [36]. The close relationship of these problems should be noted, and their interpretation in medicine should be given (figure 5.1).

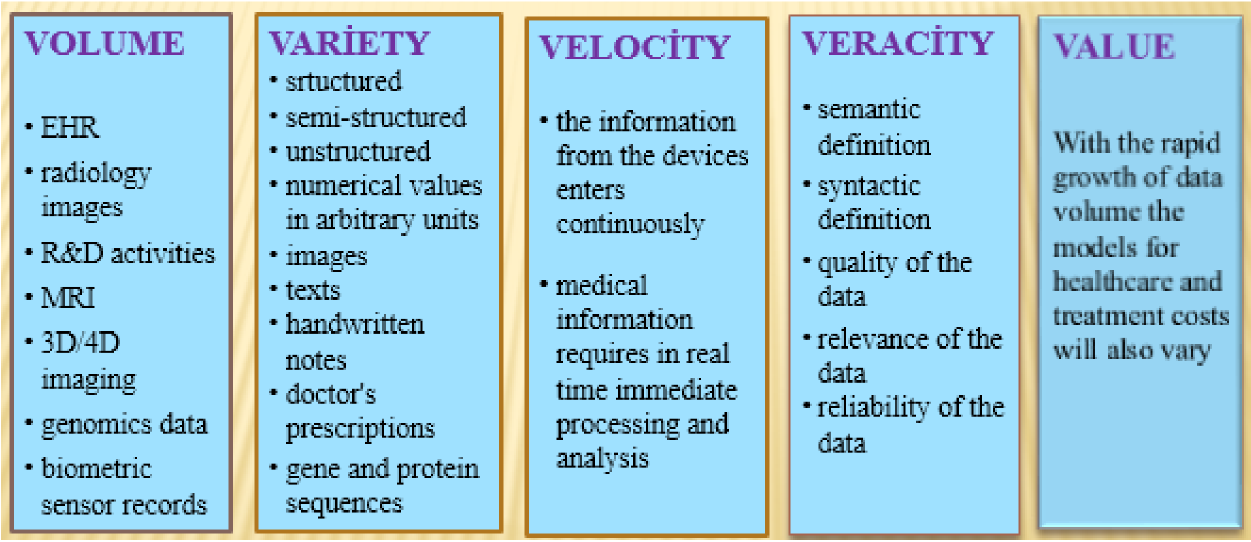

Figure 5.1. Key indicators of Big Data in medicine

Volume of medical data. Continuous generation and accumulation of medical information in the coming years will lead to an incredible amount of data [11]. Currently, medical data includes clinical data provided by physicians, as well as personal EHR of patients, radiology images (X-ray and mammography images), MRI (magnetic resonance imaging), CT (computer tomography), and etc., and laboratory and pharmacy data, insurance claims and so forth (figure 5.2). At the same time, a huge amount of medical information that is not specifically related to the patient is also generated. These are numerous medical publications, research reports, the results of R&D activities, surveys, etc. New types of medical data such as multidimensional 3D/4D imaging, genomics, biometric sensor records, etc., also contribute to the exponential increase of data. The volume of this data is very large, the results of one study can occupy hundreds of megabytes. Even annual refillable data of one clinic associated with advanced diagnostic methods can reach terabytes or even tens of terabytes. For example, in the US the volume of medical data was 150 Exabytes in 2011 [37]. The complexity and often inability of both processing and storing Big Data, as well as establishing meaningful links and arrangements between them to extract useful information requires the use of new technology and algorithmic solutions.

Variety. Simultaneous processing of medical data of various formats (structured, semi-structured and unstructured) is one of the specific problems of medicine [37]. More than 70-80% of medical data are unstructured. Furthermore, there is a steady upward trend in the information rate, relatively, to that of structured data. For diagnostic and treatment decisions, there is a need to integrate clinical information and biological data that are in different formats and generated from different heterogeneous sources. For example, medical information may be presented in the form of numerical values in arbitrary units, images, texts, handwritten notes and doctor's prescriptions, gene and protein sequences and so forth.

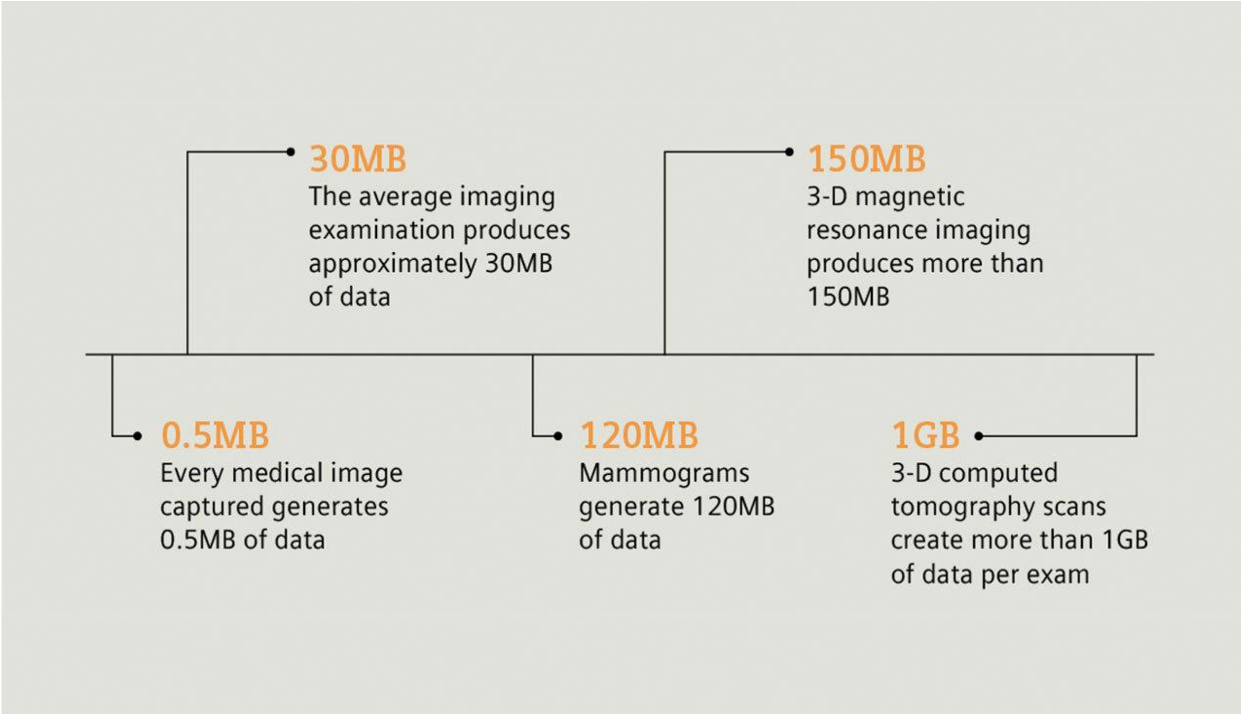

Figure 5. 2. Volume of medical data

Joint storage, comparison and conversion of different data types require solving very complex problems such as image recognition, data compression, etc. Here, medicine does not always take advantage of ready-made solutions from other areas [38]. Technology for comprehensive analysis of medical data of various formats is needed which enables them to be useful for further processing.

Velocity of generated medical data. A constant stream of new data is accumulated at an unprecedented rate, i.e., observed growth of data volume and variety is directly related to the rate at which they are generated. Specificity of the problem in medicine is that the rate of data replenishment also limits Big Data processing in medicine. Thus, the information from the devices, tracking the patients in intensive care, enters continuously, i.e. in real time, and it requires immediate processing and analysis for the timely development of preliminary diagnosis [11, 37].

Veracity. This feature reflects the semantic and syntactic definition, quality, relevance and reliability of the data. A number of issues to ensure the reliability of data are specific to medicine, as they deal with the diagnosis, treatment methods, recipes, procedures, etc. Therefore, Big Data analysis must be error-free and reliable, since a person's life may depend on the trustworthiness made by Big Data analysis. On the other hand, the poor quality of health data, especially unstructured one, is one of the major problems: medical cards filled with errors, misinterpretation and inaccurate digital input of medical appointments of the doctor in recipes, due to poor handwriting, are classified as the most common examples. Veracity of data may also depend on the quality of medical devices and sensors (e.g., wires may break and the signal may be weak due to the wrong placement of the sensor; and electrical noise may also affect the performance) [37, 39].

Too high value of the failure causes distrust of the medical community and the results of Big Data analysis.

Value of stored data. This feature, representing the interest for different parties and decision-makers, characterizes Big Data in terms of their usefulness and bringing a certain value to the medical facility (MF) and healthcare system as a whole (e.g., improvement of business processes, defining business strategies, cost optimization, etc.) [36].

With the rapid growth of data volume the models for healthcare and treatment costs will also vary. Although profit is not and should not be the main motivator, but it is vital for healthcare organizations to purchase available tools, infrastructure and the methods for effective use of Big Data. Otherwise, MI (clinics, hospitals, home health care services, rehabilitation centers, etc.) are potentially at risk of losing millions of dollars in revenue and profits [38, 40].

The analysis of characteristics of medical information on the one hand, and specific features Big Data on the other, allows to conclude about the appropriateness of the latter to handle vast amounts of medical data. Thus, the potential and the essence of Big Data in medicine, in our view, can be defined as:

1) providing storing, sharing, rapid processing and analysis of the continuously generated heterogeneous and multi-format data coming from different sources by the latest technologies and tools;

2) identifying the correlations between different and seemingly unrelated medical conditions and the factors affecting them;

3) obtaining the results of processing and analysis in the form of information (knowledge), understandable to the doctor and ready to make substantiated decisions.

5.4. Application areas and potential of Big Data in medicine

During the last decades, along with an upward tendency of healthcare efficiency, the rocketing health care costs have been observed. The problem is actualized in connection with the continuing aging of the population in many developing and developed countries and with the rapid growth in the age cohort of citizens over the age of 65, with the prevalence of such "lifestyle diseases" such as obesity and diabetes, and for the cohort of elderly

- memory loss, arthritis and etc. However, almost exhausted possibilities of extensive development of the health care system by increasing its volume, and its costs respectively, have no prospects. In this regard, today, new conceptual approaches are developed to solve this problem, considering Big Data as an additional source of compensation for costs on the one hand, and to improve the quality of medical services – on the other.

The role of Big Data-analytics in medicine. Analytics is a tool or a set of techniques that transform raw data into useful information. Big Data as an analytical basis for new IT applications in the medical industry can be used to support both medical-diagnostic and organizational and management decisions. For example, such information can be used by health organizations to support important strategic and operational decisions, to optimize expenses, to provide long-term forecasting and to create additional value. With the development of technologies and tools of Big Data analytics, medical organizations can easily manage the enormous amount of diverse and multi-format digital data from various sources. Here, the analytics plays very important role in the separation of useful information from the worthless [41]. The patient-oriented approach and Big Data as an analytical basis for new IT solutions in medicine has a potential to transform almost every field of the industry. Analysis of the literature allows us to identify a number of areas of Big Data applications in medicine, promising from the standpoint of the potential of the latter (figure 5.3) [42].

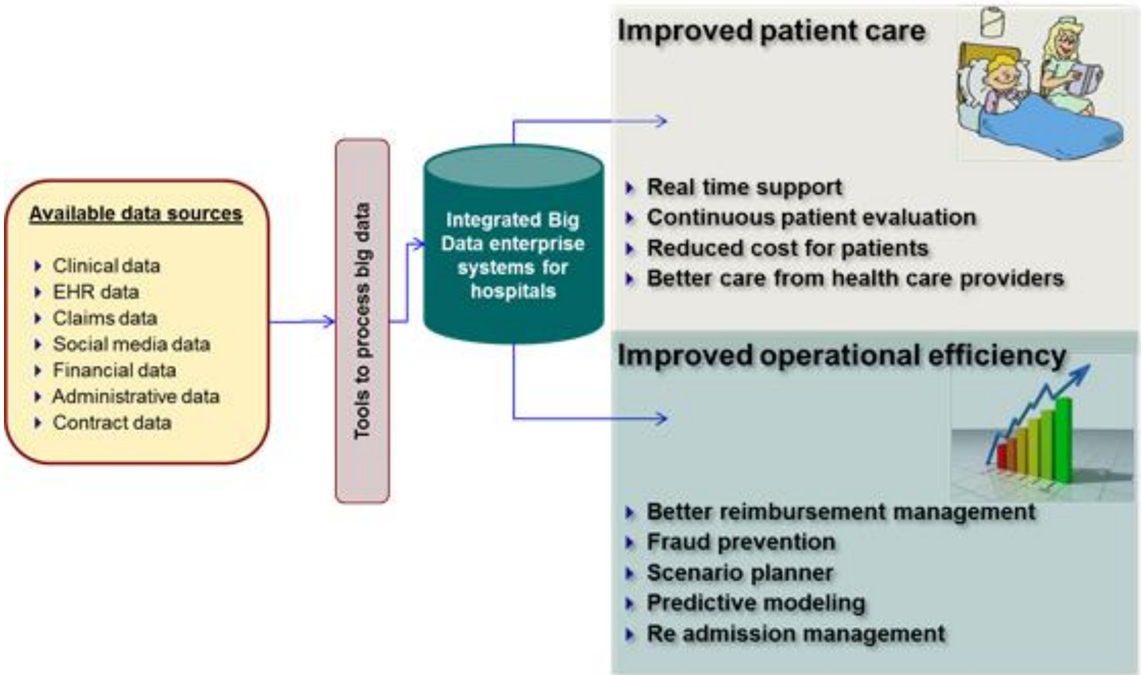

Figure 5.3. Application areas and potential of Big Data in medicine [42]

5.5. Big Data to support decision-making on management of healthcare quality

An increasing availability of medical data allows offering an enhanced understanding of the relationships that underlie the vast amount of information from different data sets and transforming the latter into new knowledge with the use of Big Data technologies. As the result of the analysis of Big Data, it is possible to identify such unexpected relationships or patterns that are not detectable by a human. For example, Big Data technologies allows simultaneously handling the databases of health records of a patient, genomic data and medical research reports and ultimately giving useful information for the best solutions with respect to the treatment of a specific patient [39].

In essence, the terms “analysis of Big Data” and “decision-making” are the implementation of process of careful analysis of a huge amount of big data to identify certain trends and making vital decisions [43].

Big Data in medical decision support. McKinsey estimates that the introduction of Big Data analysis techniques in medicine can save the US health care for about 300 billion dollars a year. The savings will work due to more timely and accurate diagnosis, appointment of appropriate treatment, and reduction of expenditure on research. It is expected that treatment efficiency will be improved by processing of all available information. Doctors will use new generation decision support systems and expert systems that provide physicians with unprecedented access to the practices of colleagues through the EHR analysis of patients both in different geographical locations and in the country. This, in turn, will enable to minimize the subjective human factor in making medical decisions about the patient’s treatment strategies.

To confirm the viability of this forecast it is enough to note that the ES Watson IBM passed the exams on a common basis in 2013 and received a medical diploma, acquiring the legal right to treat people. ES is already showing exceptional results in the field of oncology. It is able to examine the patient’s medical records,

records and comments of the doctors to view the latest research on this topic and to offer a diagnosis based on all the studied data. At the same time, IBM Watson analyzes the data in details, compares various factors and draws analogies. As the initial data more than 600 thousand of medical findings and diagnoses, 2 million pages of texts taken from 42 medical journals, and the results of clinical trials in oncology are loaded into a supercomputer memory. Watson can "analyze" 1.5 million medical records of different patients and identify the most suitable treatment methods in each certain case based on the records data of successful fight against these diseases (best practices) [44].

Currently, one of the trends of acquiring significance is clinical decision support for the management of the individual patient's health based on the aggregate data of the population as a whole. Moreover, unique advantage of Big Data analysis technologies can be very useful here, which is expressed in their ability to analyze the data of the entire population based on various demographics, as well as to segment the population by individual cohorts. Therefore, today, the data of specific patients over the past years can be compared to the results of ongoing laboratory research with the use of Big Data technologies within the same system, and additionally, this information can be linked to demographic data, retrospective information on drug reactions and drug interactions of the patients of any age, gender and ethnic background. These features of Big Data enable to build both the geographic and social model of health of the population, as well as the predictive development models of epidemic outbreaks, providing decision support for the prevention of the latter [45].

Big Data potential in the standardization of medical decisions. Each patient in his practice more than once has confronted with a situation where two different doctors very differently have interpreted the results of his tests or the same radiological image (medical data) and have made different diagnoses. Analysis of Big Data, i.e. accumulated statistical data on certain diseases, and its comparison with the current data of a particular patient (results of lab tests, X-rays, etc.), as well as with his EHR can be used for medical decision support. Minimizing the personal human factor in the process of comparison of the patient's heterogeneous data, his/her symptoms and the sheer volume of statistics on certain diseases provides the physician to select the best solution, which corresponds to the best diagnosis, i.e., promotes the standardization of medical decisions. In clinical practice, there is often a need for standardization of medical solutions. For example, in the analysis of medical errors, litigation, medical expertise, wrong diagnosis and treatment, identification of the effectiveness of prescribed medications in each case (disease). In these situations, Big Data can provide informed decisions support (revealing the truth) [46].

Big Data contribution to the creation and development of personalized medicine. Studies show that, in the near future, the quality of medical decisions will not be capable to rely on an experience and intuition: the competitive advantages will be achieved by predicting the consequences of decisions which actualizes the need to create a fundamentally new model of health care organization, so-called personalized medicine based on the concept of 4P. The medical concept of 4P integrates the notions of *personalization* (individual approach to each patient taking into account their genetic characteristics), *predictive* (predicting the vulnerability to the developing disease), *preventive* (preventing or reducing the risk of the developing disease), *participative* (motivated participation of the patient in the prevention of possible diseases and their treatment) [47]. The essence of the personalized medicine is the individualization of drug therapy in accordance with the personal data and genotype of the particular patient. As a new paradigm in the healthcare, personalized medicine involves early (preclinical) detection of diseases at the stage of prediction of predisposition and subsequent preventive measures [47, 48].

Big Data technologies can play a significant role in the realization of personalized medicine which is focused on choosing the right treatment. Hence, Big Data-based decision support systems can predict the response of the patients to certain drugs and assign absolutely unique drugs in individual doses grounding on processing and analysis of huge volumes of their genetic information [48].

The process of medicine personalization, i.e. the transition from physician-oriented approach to providing medical services to the patient-centered based on individualized medical care, is already taking place [49]. For example, more than 20% of new drugs, food and medicines approved in 2014 by the US Personalized Medicine Coalition (founded in 2004) was the production of personalized medicine [50]. In some US clinics, genotype database is integrated with the system of EHR drug prescription and the expert system to personalize medication. These fourth-generation systems classified by Gartner “physician colleagues” with advanced analytical capabilities have already begun to spread in the world [51].

Big Data potential in remote monitoring support of patients’ health. Big data processing technologies may contribute to the development of personalized and preventive medicine based on remote monitoring of patients. This, in turn, will contribute to the improvement of life quality of the patients through the access to the latest medical services anytime and anywhere, early detection and prevention of unexpected complications in the patient’s health, and through the support (automatic reminder) of the patient self-treatment and preventive procedures.

The integration of patients’ EHR (medical tests, laboratory tests, prescribed medications, information about side effects, contraindications, unstructured text, etc.) with wearable smart-devices with Internet access, controlling the vital health parameters (sleep cycles, heart rate, pressure, etc.), allows physicians to observe the patient in real time. Consolidation of the medical information, which is continuously generated in the process of patient's health monitoring, with EHR data, as well as the simultaneous analysis of the huge volume of diverse data in real time, provides the comprehensive coherent picture of the general health of the patient to the professional. This, in turn, will contribute to informed decision support by remote diagnosis of the patient in real time. At the same time, remote monitoring of patients’ health will reduce the costs, as there is no need for laboratory tests, hospitalization, and timely correction of treatment.

Future real time applications of Big Data, such as early detection of infection and the use of preventive measures, can reduce the morbidity and mortality of patients, and even prevent epidemics [11].

According to projections [37, 52], the possibility of a real-time analytics of the large-scaled data changing in all areas of medicine can make a revolution in this field.

Big Data features in the promotion of evidence-based medicine. Doctors traditionally use their judgment when choosing the treatment tactics, but a step towards evidence-based medicine has been made in the past few years. *Evidence-based medicine* is a conceptual approach to the medical practice, involving decisions about the tactics of treatment of the patient basing on reliable results obtained in the course of multiple clinical studies [53]. In other words, evidence-based medicine implies making the best decisions about treatment strategy based on a systematic review of clinical trial data.

Big data has a huge potential for the creation of an evidence base to support medical decisions. Thus, evidence-based medicine is based on the findings obtained from randomized controlled trials of a new treatment performed on a limited number of patients. But in reality, there may be quite rare nuances, adversely affecting the final results, which cannot be detected in the course of research on few samples. Combining multiple individual data sets in Big Data algorithms can provide the most reliable evidence in the choice of treatment tactics [54, 55].

Big Data potential to facilitate access to new knowledge. Digitization of medical literature also significantly extends the capabilities of doctors' access to the achievements of new research and treatment technologies introduced into the clinical practice. However, the rapid growth in the number of medical discoveries and their prompt appearance in various sources around the world overweight the physical ability of clinicians to familiarize with all the achievements, even in the context of individual diseases. Thus, for example, around 170 thousand clinical trials of drugs are annually held to fight with cancer in the world, however the access to their results is quite limited [41, 56]. Big data may facilitate the access to the latest developments in the international clinical practice, and thus, may empower the physician to quickly acquire new knowledge. Automation of examination and processing of the medical knowledge market will bring information about medical innovations, new drugs invented by leading scientists at any point of the world, to each interested person [57]. In practice of physician, Big Data may allow him to replenish or renew his knowledge by studying the data in real-time, which is collected from a variety of professionals involved in the treatment of patients with similar diseases. Improvement of the search for knowledge through access to high-performance and highly accurate databases containing the patients' health records will allow to offer prophylactic treatment, to identify successful treatment patterns and to reduce the number of medication errors [58].

Big Data opportunities to support patients' decisions on their own health control. As noted above, the digitization of the healthcare industry contributed to the transformation of most of its aspects. The most notable changes have taken place in relations between patients and health care providers: physicians, medical centers, laboratories, etc. The emergence of numerous and multi-functional wearable devices and services has had a significant impact on the imagination of patients on the principles of providing medical services. According to the results of research conducted by consulting company PricewaterhouseCoopers [59], the patients' priorities have changed a bit, and now the priority, on the one hand, is given to uncomplicated access to health services and treatment results, and on the other hand, to the need to become an active participant of the treatment process. The concept of "responsible" patient, seeking to know as much as he/she can about own health and having the opportunity to make his/her own decisions through the access to medical knowledge obtained from alternative sources, is becoming increasingly popular in the world. This, in turn, stimulates the demand for medical content and multiple patient-oriented services. The policy of many countries, aimed at improving the health of the nation and promoting the right (healthy) lifestyle also contributes to the strengthening of the trend [60].

According to forecasts, the future of medicine involves the personal participation or involvement of the patient which will be possible as a result of the emergence of new services and tools to monitor their condition. In this situation, it is advisable to provide the patients (individuals) with the opportunities to track and analyze the health status, access to the information on the treatment methods regarding their specific symptoms, allowing them to make reasonable decisions on more efficient management of their own health.

Big Data may contribute to reforming the relationship between the patients and healthcare providers for increasing the patients' engagement in the treatment process. According to the current model, EHR of the patients are at the disposal of a MI. In the future, this PMD is planned to be at disposal of the patients. Big Data will complement the PMD of patients in EHR with their personal data from various websites and social networks. In general, the further development of solutions in the field of e-health is focused on creating a platform for the transfer and exchange of information, interaction and cooperation among MI, specialist and doctors, medical workers and patients [61].

Big Data potential in forming client-oriented healthcare. At present, health service providers are striving to introduce an effective strategy for improving patient (client) retention processes by using internal, external and analytical sources to provide a unified view of the client. The emergence of new models of doctors and patients relationship due to the digitization of healthcare forced many medical organizations to adopt more client-oriented approach. At the same time, most organizations have an idea of the client based only on the internal data sources. This impedes forming a comprehensive view of the client and also requires the involvement of external data.

Big Data allows supplementing personal health data of patients in EHR with the information obtained from the external sources providing ample opportunities to identify risk factors or so-called lifestyle factors. Accordingly, in a modern digital society, each person generates a huge amount of information on the Internet through personal data on various websites, accounts in social networks, using credit cards, etc. This information allows revealing the lifestyle factors of a person (for example, material condition, education level, habits, interests, possible diseases, etc.) without the need for interviewing the latter. Cooperative use of "network" information and the patient data from the EHR provides a unique opportunity to integrate traditional medical models to the social determinants of the patient's health and the formation of client-centered healthcare [62].

Big Data potential in managing the treatment of the patients with chronic diseases. Over the past few decades, there has been a significant increase in the number of the patients with chronic diseases almost all over the world. The indicators of comorbidity, i.e., simultaneous presence of two or more chronic diseases in the patient have also significantly increased [63]. This requires the patients to be monitored not only by their primary physician, but also by other specialists. However, the disparity of both health facilities that provide different services to the same patients and the treatment methods reduces the ability of the health system to provide quality health services and leads to unnecessary duplication of analyzes and treatments. In this situation, the patients requiring comprehensive medical care are at greatest risk.

For example, a patient with congestive heart failure, diabetes and chronic lung disease needs a comprehensive treatment that ensures the coordination and the balance of various therapies. However, in practice, such coordination is rarely carried out. Instead, the patients often receive contradictory recommendations from various doctors.

For today, the patients suffering from chronic diseases are the largest consumers of health resources. For example, their share in the US health care accounts for 75% of the costs of this sphere [64]. Big Data can play a decisive role in reducing the costs of the treatments of the patients with chronic diseases.

Consequently, using data mining methods, the most similar cohorts of patients perceived as the candidates for a preventive intervention in a high-risk group (Highriskgroup, HRG) can be found [65]. This may reduce health care costs by:

1) improving the coordination of the patients' care;

2) detecting the data duplication and clarifying the therapy;

3)reducing repeated hospitalizations through the identification of lifestyle factors (hereditary, socio-economic, professional, environmental, behavioral, etc.) which increase the risk of deviations in health status;

4) forming the client-centered healthcare.

5.6. Big Data opportunities in organizational and managerial decision support

Analysis of existing medical practice using the Big Data technologies may reduce the hospital costs, eliminate many misapplication and extra costs in public health systems. Thus, MIs may reduce the costs by using huge volumes of diverse data about the patients and by optimizing the work of clinics: predicting the expected flow of the patients, reducing the queues, optimizing the resource provision, assessing the medical personnel performance and its workload balance, improving the patient satisfaction with high quality of medical services and etc [66].

With the help of Big Data technologies, it is possible to improve and regulate the pricing and payment system. For example, in the United States, in accordance with the new federal laws in MIs covered by the Medicare program, the performance of medical personnel is directly related to the payments and fines for medical services measured by such factors as patients' expenditures, their satisfaction, rehospitalization and mortality. Approximately 90% of medical services in the US is predicted to be paid under the Medicare program by 2018 [67], i.e. depending on the results of the treatment. The shift to the introduction of the payment and pricing system based on a joint assessment of the performance of medical personnel, the cost of medicines and labor, the real financial capacity of the population and the need for services, is possible only on the basis of the systems working with large-scale data.

MIs are tending to improve the quality of patient care while reducing the costs. To improve their performance, MIs are trying to use and analyze large volumes of heterogeneous internal and external data about the patient: clinical data, EHR data, monitoring data of medical devices, data continuously received from monitoring systems (lifestyle devices), and so forth. This enables them to improve the quality and diversity of health services provided to heterogeneous groups of patients. The growing involvement of patients in their own healthcare and the demand for remote health services enables MIs to agree on better payment terms by payers (patients, insurance companies and regulator) [68]. Big Data technologies can also play an important role in extracting and providing valuable information from a huge amount of data to healthcare providers and decision makers to develop strategies, plans and to make important managerial decisions.

5.7. Advantages of Big Data and proper analytics to support appropriate medical decisions

Generalized advantages of Big Data in medicine can be expressed in their assistance to improve the quality of medical services and additional cost reductions through:

- the possibility of analyzing medical datasets, and therapeutic and diagnostic decision support both in the context of the entire population and its geographic sections, and across different cohorts and individual patients;
- the development of evidence-based medicine by supporting more informed treatment strategies;
- development of personalized medicine based on an individual approach to the prevention, diagnosis and treatment of genetic diseases;
- automated consolidation of patient’s data from the complex heterogeneous sources and its sharing in real time;
- identifying the most similar patient cohorts, who need complex medical care, and coordinated decision support on their treatment;

- making organizational and management decisions to reduce costs, modernize the payment system and pricing.

5.8. Challenges in using Big Data-analytics in medicine

Along with the potential of Big Data and growing trend of practical use of the latter, there are certain challenges to their widespread introduction in medicine (figure 5.4). Thus, an effective Big Data-analytics prevent are prevented by:

- continuous growth of medical information, only a small portion of which is used all over the world;
- dominance of unstructured, incomplete, inaccurate and accidental medical data in EHR system, affecting the precision of the information (inaccurate digital input of medical appointments in recipes due to poor handwriting, poor quality of the information obtained from remote sources, the lack of information in one or more fields of EHR, increased garbage, etc.) [37, 69, 70];
- complication of the exact identification of the patient's identity when comparing the data obtained from a variety of sources (EHR, non-clinical data from social media, web sites, etc.) in order to form a complete picture of the patient's health [39, 71, 72];

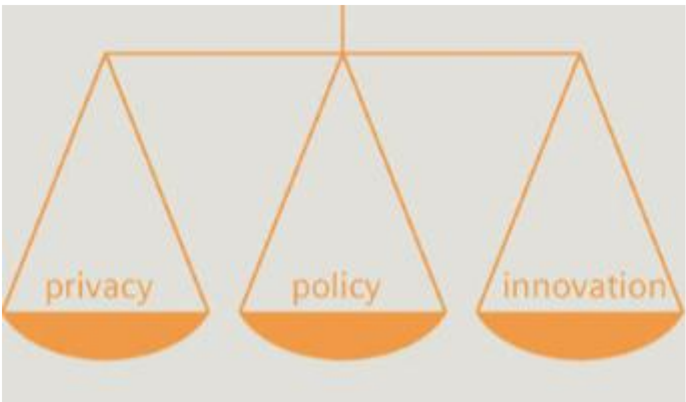

Figure 5.4. Big Data in medicine: challenges [37]

- growing demand for processing continuously generated data of the patient and the generation of analytics in real time, which requires the implementation of complex integration processes that are not available to many clinics due the high cost of Big Data technologies, and the lack of appropriate specialists in the IT departments of MI. The latter must also ensure the safety, reliability and high availability of data from different sources [73];
- potential threats to privacy and information security of personal medical data, related to the risk of misuse of the latter. Another serious threat to the security of personal health data occurred after the wide availability of genetic information, clearly indicating the certain patient. Since this information is almost impossible to anonymize, and de-identified genome data is easy to be recovered, then the privacy issues need to be resolved at the legislative level [38, 74, 75];
- insufficient volume of accumulated information resources due to lack of EHR and EMR, various warehouses of medical data in many countries;
- lack of specialists with deep analytical knowledge to work with Big Data (Data Scientists), which is estimated to reach 140-190 thousand people by 2018 [5, 76];
- high cost and complexity of adaptation tools, methods and algorithms for the analysis of Big Data limit the scope of healthcare organizations that have the ability to implement these technologies. Additional obstacle to the implementation of Big Data is a need for the continuous financial support for databases update. For example, IBM invested about 3 billion USD in the development of Watson, and supercomputer took “training course” only on a few diseases [77].

5.9. Technologies and methods of Big Data processing and analyzing

In accordance with [78, 79], the term “Big Data technology” implies the approaches, sets of tools (platforms), methods and techniques (procedures) for the processing of huge volumes of multiple data in various formats to achieve the results to be perceived by human.

Methods and techniques of Big Data analysis. Quite a wide spectrum of methods and techniques have been developed and adapted for the unification, storage, manipulation, analysis and visualization of Big Data. These methods and techniques are borrowed from many fields, including statistics, computer science, artificial intelligence, applied mathematics, linguistics, etc. Without pretending to be exhaustive, we list some of the methods and analysis techniques of Big Data, allocated in the works [5, 44, 80]: Data Mining methods, crowdsourcing, integration of heterogeneous data, visualization, statistical analysis, predictive analytics, predictive modeling, machine learning, natural language processing, artificial neural networks, learning association rules, classification, cluster analysis, regression analysis; artificial neural networks, network analysis, optimization, genetic algorithms; pattern recognition, etc.

Big Data processing and analysis tools. The basic requirements to the development of software systems for working with big data is the inclusion of parallel processing tools and distributed data storage, as well as the transition from models used in traditional relational databases to the new models supporting the constant change of data structures, and the horizontal scaling through the clusters of inexpensive commodity computers, etc. For example, a new class of NoSQL systems (Not Only SQL), such as HBase, Cassandra, MongoDB, Neo4j, Riak and etc. are the explanation of advanced relational SQL databases [81].

The most common Big Data processing systems are Hadoop platform and distributed computing paradigm MapReduce.

Hadoop is capable to handle very large volumes of heterogeneous input data mainly through the distribution of the latter on multiple servers (nodes), each of which produces the processing of a specific set of data, and then the results of the subtasks are reduced to the final (conclusive) result. This enables the use of Hadoop for the implementation of search and contextual mechanisms of heavily loaded sites, as Yahoo, Facebook, Amazon, and etc. Making Hadoop code public by Yahoo has contributed to the emergence of the whole field of production, based on Hadoop, in IT industry, the developers of which are both well-known global companies and start-ups.

In recent years, many software products have been developed that facilitate the work with Big Data, including SAP HANA, high-performance platform NewSQL for data storage and processing, the applications for pre-processing of information flows (Marshalling), solutions for visualization and self-analysis (Advanced Analytics with Self -Service Delivery), and others. The most popular programming languages are Python, Java and Scala.

Availability of Big Data technologies has significantly increased due to cloud computing which provides a new level of processing speed [82]. There are many cloud services in Big Data analytics, and cloud platforms for application deployment. With their help, Big Data analytics can be used “anytime and anywhere”, simply by connecting to the Internet and selecting the appropriate service.

It should be noted that, today, in the process of introduction of the newly developed software in medicine, the users face a number of significant shortcomings associated with the specifics of the industry, which need to be addressed. Furthermore, the offered platforms/tools require specialized programming skills, which is not typical for an end user of health care. Since Big Data analysis technology has been recently used in medicine, a number of problems related to the data management, privacy, security, standardization, etc. have to be resolved.

5.10. Development prospects of Big Data in medicine

According to ABI Research, currently, the processes of Big Data analysis in medicine are in the early stages. However, according to the forecasts, as a result of the rapid growth of continuously generated data, the market of Big Data-analysis will make up approximately 52 billion USD by 2019 [73]. TechNavio analysts predict the increase in the cost of the global Big Data market in the field of medicine for 2014–2019, with an average annual growth rate of 42% [83].

Here are the most promising areas of development and implementation of Big Data in medicine [84–88]:

- development of mobile medicine, which expands the capabilities of remote diagnosis and continuous monitoring of the health status of certain categories of patients, that actualizes the demand for streaming processing of the information through the development of analytics basing on the patient's data set in real-time;
- promoting technologies to support informed diagnostic and treatment decisions based on a comparative analysis of the patient's data with the EHM databases containing the treatment practices of similar diseases and identifying the most suitable treatment method in each case;
- expanding the introduction of Big Data in the realization of personalized medicine;
- expanding the basic research in the field of optimal methods of processing, analyzing and extracting useful knowledge from large volumes of medical data of various nature;
- personnel training to handle big medical data;
- development and adaptation of the tools to handle Big Data for the medical industry: development trends in the field of mobile applications, cloud infrastructure, data visualization, etc.
- Big Data-solutions for the processing of medical data generated by “smart” devices within the framework of the exponentially growing Internet of Things.

Conducted analysis of the status of Big Data in medicine shows that, at present, this segment of the market is in its early development stage. However, all the growing digitalization of medicine, the conversion of the Internet into one of the most powerful medical information sources and infrastructure for fast, reliable and secure data transmission, the development of social networks, mobile and wireless access to health information have contributed to the transformation of many aspects of the medical industry, and have led to the emergence of new trends. We can point out a number of new trends, such as:

1) development of person-centered medicine, implying effectively organized access to any set of medical records and the primary results of the patient's examination;

2) changing role of patients, their increasing involvement in their own health care and the possibility of self-monitoring;

3) changing methods of interaction between doctors and patients, and the access of the latter to health services, treatment results and medical information;

4) delivery of medical services in real time;

5) development of personalized medicine, based on the individual patient sensitivity to drugs, when appointing the therapy, etc.

All these transformations are taking place at the background of a common goal, focused on improving the efficiency and flexibility of the health care system by increasing the quality of medical services and reducing costs.

Big Data can have a significant impact on the healthcare. The enormous amount of data currently generated by medical institutions will grow at an even greater rate in the coming years. This will inevitably lead to an increase in demand for Big Data analysis. Extraction of the useful information from this data can be of great importance for the development of new methods and treatment technologies, the identification of diseases and their prevention, reducing the number of medical errors, ensuring the total security of the health of the population, perfecting the health care system towards the evidence-based and personalized medicine.

This will result ultimately in improved treatment and reduced number of patients and consequently, medical facilities costs.

It should be noted that, although potentially Big Data in medicine can help to address many problems, today, there are very few actual examples of successful application of this new technology in medicine. Analysts and practitioners see the reason in the lack of adaptation of Big Data platforms available on the market to the specific characteristics of the healthcare industry, to the requirements of confidentiality and security of medical data, as well as to the standardization of medical solutions, etc. Implementation of Big Data in medicine is also affected by the factors, such as distrust of doctors and the uncertainty of a number of IT companies, in the effectiveness of these technologies. This means that the use of Big Data in medicine passes through the solution of mentioned problems and the improvement of these technologies. The development dynamics of Big Data technologies and services, as well as the analysts' forecasts reinforce the confidence that, in the near future, there will be a significant increase in the application of Big Data-solutions in medicine. Moreover, according to latter ones, the further digitalization will inevitably pave the way to revolutionary changes in medicine, the consequences of which will be much bigger.

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CHAPTER 6. INTERNET OF THINGS AND ITS APLICATIONS IN E-HEALT

Modern Internet-enabled things and devices are becoming an integral part of many HIs, providing a significant increase in the quality and availability of medical services, reducing the cost of medical service, and enabling the patients to benefit from the advanced services and consultations of the best doctors in the regions with the clinics unequipped with high-technologies. Internet-enabled medical equipment senses and transmits data about patients within a few seconds. The Adaptive Intelligence System allows the patient to monitor and display a wide range of data transmitted from various wearable transmitters and implants, as well as to perform real-time data analysis and to predict unpleasant situations. The devices that identify and alert about the changes representing the consequences of insufficiency and heart defects are now available in the market.

This chapter explores the concept of "The Internet of Things" and highlights the capabilities of IoT in e-medicine, wearable smart IoTs, smart IoT services and applications, and the technology used in medical IoTs. Moreover, it focuses on the opportunities provided with IoT’s integration with cloud technology, Big Data and artificial intelligence technology, and the risks and challenges associated with IoT's application in medicine.

6.1. The term of the "Internet of Things"

The concept of the "Internet of Things" was first used by the English innovator in the field of technology Kevin Ashton in 1999 for the description of the system in which the objects of the physical world were connected to the Internet through transmitters. In the same year, the Massachusetts Institute of Technology established the Radio Frequency Identification (RFID) and Auto-ID Center, and respectively, the concept of IoT has gained a wide range.

The simple idea of the Internet is that surrounding objects or things (such as tablets, smartphones, fitness equipment, home appliances, clothes, cars, manufacturing equipment, medical equipment, medicines, etc.) can be equipped with miniature identifiers and sensors (sensitive devices) and can be connected to the Internet and to each other via wired and wireless (satellite, mobile, Wi Fi and Bluetooth) connections [1, 2]. Availability of the necessary channels allows not only to identify and monitor the parameters of these objects by space and time, but also to manage them. Thus, the "Internet of Things" can be viewed as a global network infrastructure consisting of a large number of devices, interconnected through sensors, communication, networking and information technology [3].

From the information-communication point of view, the Internet of things can be typically written as a symbolic formula as follows [4]:

IoT = Sensors (Transmitters) + Data + Network + Services

At present, the term "Internet of Things" does not have a single universally accepted definition in literature. Many definitions of IoT focus of its various aspects and features [5–7]. Some of them are listed below.

1. The Gartner analytical company interprets the "Internet of Things" as a network of physical objects based on technology that allows measuring the parameters representing the position of the physical objects as well as their environment, and using and transferring this data. The main aspect of this interpretation is that, despite the notion of "the Internet of Things", the things are often linked via the M2M (machine-to-machine) protocols rather than the Internet. In this case, it is focused on decisions based on the interactions of transmitters, sensors and other "iron" things without the participation of people [8].

2. The Internet of Things – physical devices connected to the Internet - a global network of "things" equipped with data transmission facilities that enable sensors, transmitters and data collection and share ("communicate" with each other). These

facilities are connected with data management, control and processing center access tools [9].

3. The International Telecommunication Union defines the Internet for Thing as a global infrastructure for the information society, providing the opportunity to deliver more complex services by connecting physical and virtual objects based on existing and emerging ICTs [10].

4. The Internet of Things is a computing device integrated into the daily objects and connected through the Internet which provides data sensing and transmission [11].

Due to the rapid development of technology, various interpretations of IoT are given, though they are all based on the same concept. According to this concept, IoT is a group of non-computerized devices, equipment, transmitters and routine tools with computing capabilities and network access (figure 6.1). Most of these devices are usually referred to as "intelligent devices" that can process and utilize, analyze and share data with minimal interference of human.

The number of Internet-connected devices increases at a high pace. These devices may include personal computers, laptops, tablets, smartphones, personal pocket computers and other handheld devices. In this regard, IoT is referred to as the transition of the Internet to a new quality or stage, where not only people but also things interact, transact and affect one another. According to the estimations of Cisco experts, the number of Internet-connected objects exceeded the number of people in 2008-2009, and in 2020, the relevant figure is estimated to reach 50 billion. Thus, currently, the civilization is experiencing an evolution period of the transition from "the Internet to People" to “the Internet of Things” [5].

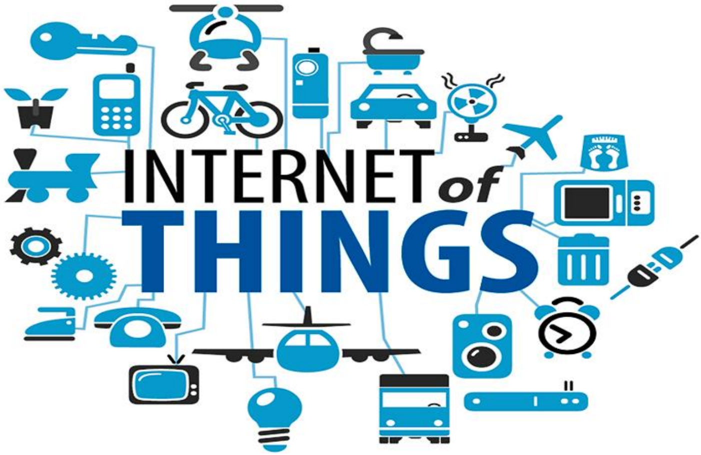

Figure 6.1. IoT group [12]

These things interacting and communicating with each other, and sharing information about the environment and responding to environmental processes without human intervention are predicted to be the most active participants of business, information and social processes in the future [13, 14].

The differences between "the Internet of Things" and "the Internet to People" are as follows:

• focusing on things rather than the people;

• considerably vast number of connected facilities;

• very small dimensions of objects and high data transmission rate;

• focusing on information computing rather than the communication;

• importance of creating new infrastructure and alternative standards;

• communication of arbitrary devices or things (figure 6.2).

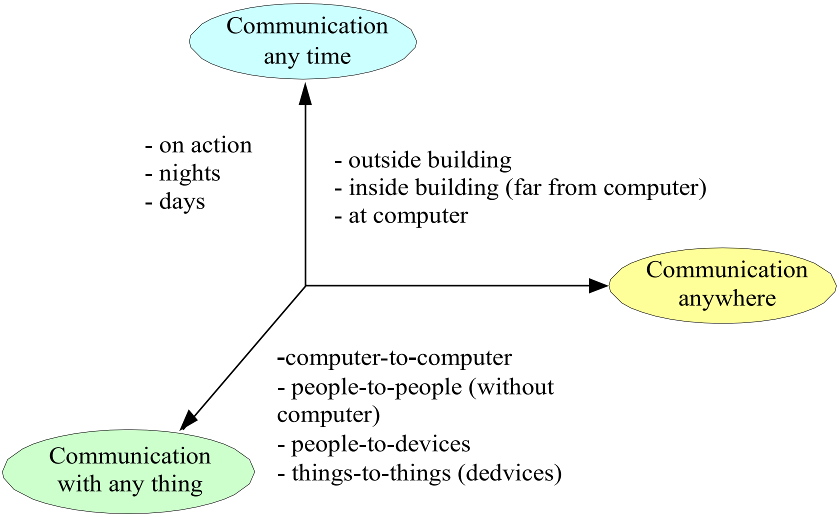

Figure 6.2. New communication trends realized through the Internet of Things [10]

Communication models of different kinds of IOTs are based on the directive prepared by the Internet Architecture Board (IAB) where a conceptual framework for networking architecture of intelligent objects (RFC 7452) and the conceptual basics of four common communication models [16 MSE] are presented [15].

6.2. IoT technologies in e-health

In 1998, WHO recognized the growing role of the Internet in healthcare and its potential, and first used the term e-Healt in 1999. At the same time, this definition was widely comprehended as the overall informatization of healthcare sphere. In 2013, the importance of standardization of health data within the eHealth system of the World Health Assembly was adopted in Geneva [16]. The term m-health (mobile-health), which envisages the use of mobile wireless technologies and wearable transmitters for public health, was first used in 2016 [17]. The latter incorporates

6LoWPAN technology with the developing 4G networks. In this context, "e-medicine/e-health" can be interpreted as the monitoring of the population’s health through the patient's treatment, tracking the diseases in the medical sphere with the use of data collection tools and data transmitters.

e-Health is one of the most important areas of IoT technology that can contribute the community. Currently, special definitions are used in this area - the "Internet of Medical Thing" or "The Internet of Things in Medicine". Recently, IoT researchers and creators have focused on almost all segments of medicine, and IoT technologies are applied in the solution of a number of practical issues. As a result, many applications and service areas have been created. Large-scale research and experiments on the integration of ICT innovations into the medical practice demonstrate a great potential of this technology in healthcare.

It is no coincidence that, at present, medicine determines the growth of the IoT segment. The main reason for this is the availability of mass and direct interaction between human and compact electronic devices. According to the forecasts of *Allied Market Research*, the revenue of the market of medical IoT-devices and IoT-applications is estimated to be increased by 136.8 billion USD in 2021. The average annual growth rate of the market of the Internet of Medical Things accounts for 12.5%. Moreover, the number of high-tech services, applications and systems in the field of healthcare is also estimated to be increased. The growth of the market is regulated through the increasing availability of medical supplies and the awareness of the users about medical innovations [14, 18].

6.3. Opportunities of IoT for the development e-medicine

IoT-based solutions constitutes the further development of e-medicine. IoT technology enables the improvement of the efficiency of work at MI, reduction of hospital stay, delivery of new services to the patients, control of patients’ health, access to the additional data on the treatment progress and its analysis, and provides the consultation with the best doctors. Remote health monitoring ensures the maintenance of operational control of health data, reduces the costs for healthcare services, and simplifies the relationship between physician and patient.

IoT devices, different sensors and related analytical applications are involved in addressing a number of administrative, logistical and diagnostic issues. The global connection of the Internet of Things ensures effectively collecting, processing and using various types of health data related to security, diagnostics, therapies, treatment, medications, management, finance, daily activities and so forth [19, 20].

The practical issues that have been successfully solved through IoT technology in a number of medical spheres are specified below [21–26].

Administrative management. In the development of the administrative management segment of e-Medicine, IoT technologies have great potential for the solution of the following problems:

- monitoring the patient and tracking his/her health condition (fever, pressure, and other physical symptoms);
- real-time surveillance of doctors and patients at HI (this allows for emergency calls in case of important situations, such as operations or procedures);
- monitoring the environmental parameters, monitoring the climate change and exceeding of certain indicators (e.g. temperature, humidity, oxygen concentration, etc.) at HI and separate hospital rooms for warnings;
- managing the medicines and consumables at HIs and pharmacies, monitoring the status and condition of medical equipment;
- implementing automated inventory and reporting on

the intensity of the use of medical equipment and information technology.

In these cases, transmitters are placed in hospital refrigerators, ice chambers, hospital rooms, corridors or at other locations of the HI.

Medical Diagnostics. Medical diagnostics covers various measuring tools, and thus, the potential of IoT in this area is practically unlimited. In addition to traditional "visualization" (e.g. ultrasound, magnetic resonance and computer tomography) and laboratory diagnostics, the transmitters for measuring clinical indicators (heart rate, arterial pressure, pulse, head and brain activity) and micro-transmitters and nano-sensors for clinical biomarkers' evaluation are widely used. Today, laboratories are widely using nano-size biochips, such as in vivo (lat. live), more precisely, to implement a sensitive analysis "inside a living organism or a cell". Significant progress enables to identify the cancer biomarker and the infection microorganisms for molecular diagnosis and genomics. For example, a unique biosensor with a total length of a centimeter developed by Swiss researchers is implanted underneath of skin allowing them to track the patient based on the sensed data related to glucose, cholesterol, toxin and so forth sent to the patient's phone (figure 6.3). The device is charged by a special plaster stuck on the patient's skin [27]. Portable, implanted and absorbed sensors that sense a variety of vital data can be integrated to the patient's smartphone, and can also "communicate" directly with the treating physician.

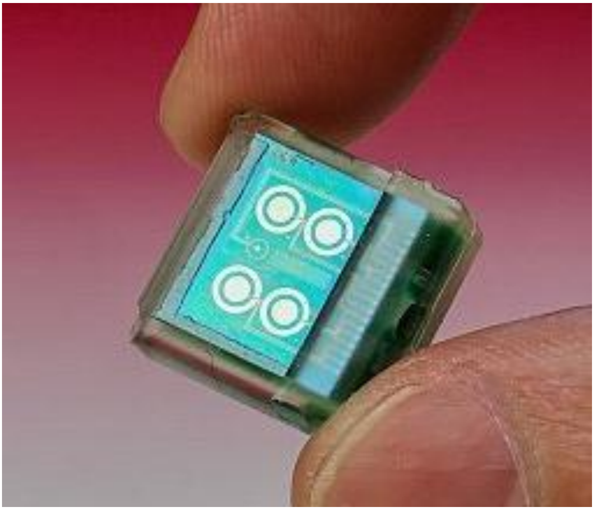

Figure 6.3. A unique biosensor transmitting glucose, cholesterol, toxin and other cdata to the patient's phone [27]

Remote monitoring. IoT-based remote monitoring is an integral part of modern telemedicine and telemetry. Portable transmitters allow doctors to remotely track vital functions of the patient, to conduct real-time data analysis and predict the changes in their health. At present, various diagnostic complexes equipped with transmitters are available for the remote monitoring of cardiac rhythm, body temperature, blood pressure and for real-time processing of blood glucose levels and breathing functions.

The signals received from the transmitters are sent to the patient's mobile device and the medical server (to the displays of the medical stuff and doctors of the patient). The analyses are supervised by a physician, and the conditions are specified for life-threatening situations. The patient can also send an alarm signal to the server from the interface of his/her phone [28].

Drug therapy is one of the medical spheres that will greatly benefit from IoT. Nowadays, micro-transmitters mounted on the pills have been proven to be effective in the monitoring of the effectiveness of drug therapy, and they help to monitor taking medication and its compliance with the schedule. Such implants can be "directly" connected to the patient's smartphone, as well as the relevant physician. At present, the devices, which control the proper and regular use of drugs and send notifications, are widely spread on the market.

Miniature microchips that form part of the pill are produced by *Proteus Biomedical* (USA) [29]. Microchip battery does not work, that is, when the human body goes down (by absorbing the tablet), there is a potential that signals of the action activity are sufficient to transmit the patient to the ECG and the radioconality to the tube attached to the wall of the abdomen.

The receiver accepts signals from swallowed pills and then transmits them to the server or to the doctor's computer. For the first time, such chips have been permitted for FDA use [30].

Philips has developed a "smart pill" (*Intelligent Pill, iPill*), a miniature device consisting of a container for microprocessor, battery, radios, pumps and medicines [31, 32]. This device puts the drug in the place where it is needed.

When the "smart pills" fall into the human body, they define the dose needed by minimizing the harmful effects of the drug. The *iPhil's* "electronic brain" consists of a control microscope and transmitter that controls heat and acidity, as well as a small pump (figure 6.4). The microprocessor transmits the data collected from the sensors and transmits the voltage to the "pump", which is necessary at the current time. *iPill* can be programmed to perform the drug at one time or at a specified time intervals.

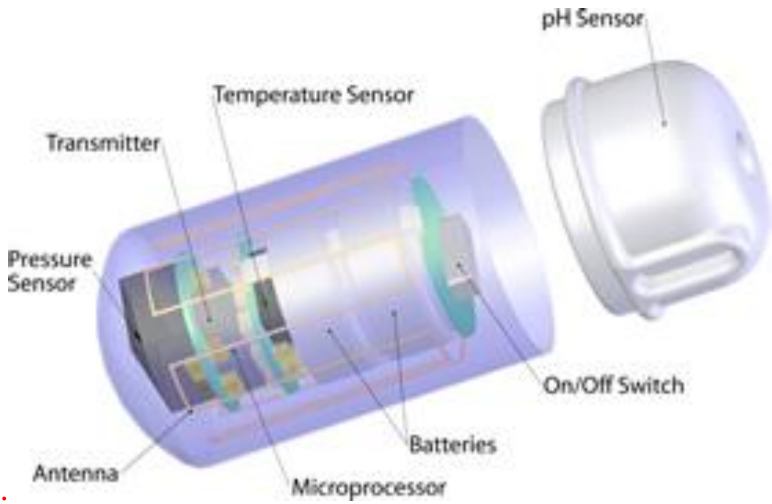

Figure 6.4. Microprocessor, released by Philips, a "smart tablet" [31, 32]

Treatment and care. IoT has great opportunities in the treatment and care of patients at both a health facility and at home. According to the growth rate of IoT in health, many people can live in more comfortable conditions, and their health indicators are routinely sent to the treatment physician who is responsible for monitoring the patient's health status through transmitters. The staff of the clinic analyzes the health of each patient on the basis of the requirements of the relevant technology, identifies the needs of the patient and teaches him to use the IoT-supported devices. IoT has a great potential for the treatment of patients in the operation, other urgent care rooms, separate intensive care and postoperative care units. In this case, transmitters may be used to measure clinical signs (heart rate, arterial pressure, pulse, brain activity, etc.) in the broad spectrum.

Personalized IoT platforms and health data analytics allow medical staff to monitor the situation and notify about the need for medical intervention. IoT solutions focus on home-based care more, rather than on an ambulance. The use of IoT technologies reduces the cost of medical services due to reduced demand for emergency care and visiting hospitals. IoT devices, services and applications used in e-medicine and communication technologies are provided below.

6.4. Portable intelligent Internet of things in e-medicine

At present, the continuously expanding market of medical Internet o things have been applied in many healthcare sectors. Thus, many health centers around the world have been using smart clothes, gadgets for sensing data on key health parameters, climate control platforms in hospitals, applications for transferring health data to physician, and so forth. For interconnection of different devices with different applications, they are combined with different types of networks over the Internet.

Note that various types of medical Internet of things are referred to the large number of intellectual devices that are easily accessible in our daily lives. They are portable (in bodies) intelligent Internet things.

Today, there are numerous body-worn wearable devices that measure human physiological parameters [33]. Portable biomedical transmitters are the subset of devices measuring human biological parameters. Portable IoT technologies are typically rigid or flexible, based on ordinary electronics, and are designed for low power consumption. They are able to control the patient's parameters in a natural environment and an arbitrary environment, and to transmit signals and information. In the market of the medical Internet of things presents various portable technologies installed on the transmitters that are categorized as "smart clothes" (head covers, space suits, helmets, jackets, trousers, coats, socks, etc.) and "smart things" (glasses, watches, rings, bracelets, sticks, bandages, lens etc.) (figure 6.5) [34].

Figure 6.5. Health IoTs: "Smart Clothes" and "Smart items" [34]

"Smart Clothes" can be used to sense and analyze the data related to the physical activity of a person, to control vital health indicators. They can control the state of people working in hazardous conditions, and monitor the location of the patients and their place of residence in emergency situations, and to observe fatigue levels of an oil man, pilot, driver, etc.

"Intelligent things" (gadgets or devices) may include body-worn transmitters, the objects to monitor vital health indicators, to track the location of the staff on SP, and the applications or objects (e.g. smart box for ampule/pills) reminding the stuff, as well as the healthcare personnel observing their physical state (both physicians), smart devices for real-time monitoring of critical health status, transmitters for tracking and transmitting geolocation data.

Note that each wearable smart gadget has certain functional capabilities and is intended to address specific issues. This allows classifying the portable IoTs for their functional capabilities and relevant applications.

Essentially, portable medical IoTs can be grouped as follows:

1) IoTs for monitoring, diagnostics, treatment, care and rehabilitation of personnel;
2) IoTs for supporting healthy lifestyle of staff, including their daily physical activity and physical condition;
3) Transmitters for tracking staff displacement.

First-class devices include measuring and analyzing one or more vital indicators and parameters (cardiac frequency, ECG, arterial pressure (smart tonometer), sugar rate (smart glucometers), respiratory rate) characterizing the functioning of the cardiovascular system, and the transmitters for drug control.

Second-class portable devices are designed for continuous monitoring of the level of human agility (SP employee), and shows the data, pulse rate, distance traveled, calories consumed, and so forth sensed from accelerometers. The sensed data can be transmitted to the employee's smartphone or computer as well as to the medical personnel (physicians) who treat them. The applications specifically designed for the calculation of various human health indicators provide advice to users when they detect abnormalities in these indicators, and notify the healthcare personnel in critical situations (insult, heart attack, epilepsy, etc.) and for emergency medical intervention.

Third-class mobile devices can be used successfully for tracking the location of people at high risk areas, including people from vulnerable categories (elderly, children, people with psychological illnesses).

However, the experts and professionals believe that these technologies are temporary, and in the future they are predicted to be implanted and placed inside the human body. In the near future, the implanted and absorbed sensors for the measurement, analysis and analytics of a variety of vital health indicators will be widely applied.

The medical IoTs market is now extending to many types of treatment chips, blood vessel robots, electronic pills with feedback, melted nutritional batteries, sensor bionic vision and eye, *Smart Dust* micro-devices, and these in-body things will be self-improved on an arbitrary network.

Transmitters implanted into the human body collect the necessary information by transmitting the data on blood pressure, blood sugar level, heart rate and other important vital signs, and control the dosage of the necessary preparations using the Internet.

In addition, people will be able to receive as much of the medicine as they need at any time. The transmitters and implants will transmit the data to each other and the physician, assisting robots will assist the doctors during the operation, and nanobots will help the therapists to track the condition of patients from different cohorts and inform them about medical concerns. The electronic device monitoring the situation immediately sends a signal to the doctor or an emergency to respond.

A new dimension, namely the *Internet of Nano-Things (IoNT)*, which includes the installation of nanosensors in different objects and devices covering users, is expected to be added to the concept of the Internet of Things. Such miniature sensors, connected through nanonetworks, will enable to sense even the smallest structured (least significant) data inside the body, installed in the least accessible objects and locations [2, 22, 34, 35].

6.5. Intelligent IoT-services and IoT-applications in e-health

IoT opens up extensive opportunities for the development of new services and applications that:

1) increase the quality and effectiveness of medical care;
2) collect, analyze and interpret various types of data;
3) improve real-time decision-making;
4) enable the permanent monitoring or preventive intervention of old patients and those with chronic illness;
5) create favorable conditions for the development of individual and personalized medicine, etc.

There is no standard definition of IoT service in the context of healthcare. IoT technology is expected to provide a variety of medical solutions ensuring healthcare services. However, in exceptional circumstances, the service may be objectively allocated from a specific solution or application [36]. Additionally, note that general services and protocols essential for IoT infrastructure may require minor changes in the functionality of healthcare scenarios they refer to. These may include notification services, joint resource access services, Internet service, cross-switched protocols for heterogeneous devices, and merging protocols for key connection capabilities. It should be noted that the services are directed to their creators, whereas the applications are used by users and patients only. Currently more accessible and disseminated IoT-based medical services and applications (IT solutions) are shown in figure 6.6.

Public health. Rapid growth in healthcare expenditure has been a challenge for many countries worldwide. In many developed and developing countries, the tendency of aging population, and significant increase in the number of patients with "lifestyle disorders" (obesity and diabetes, memory problems, arthritis, etc.) and chronic illness are the major factors of the extensive development of the healthcare system [37].

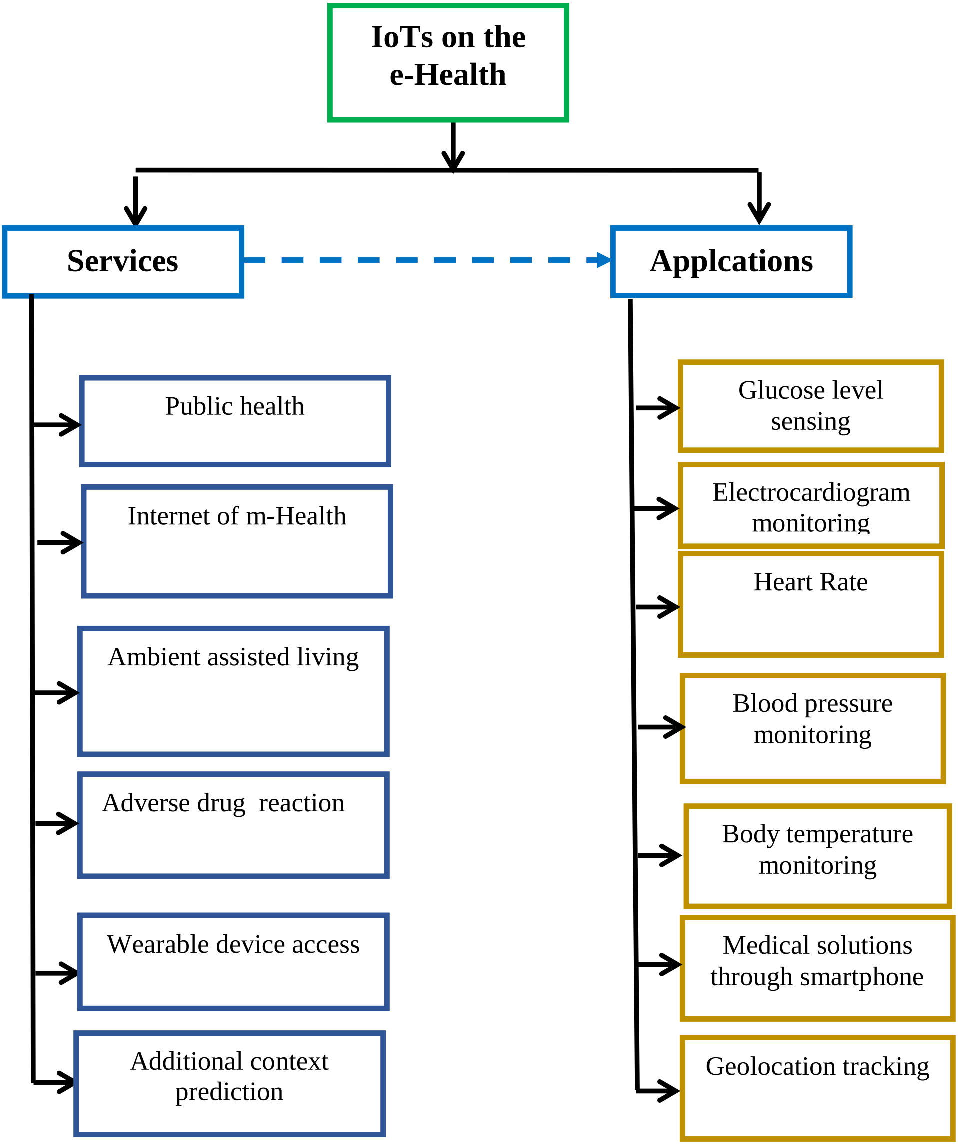

Figure 6.6. IoT-services and IoT-applications in e-health

Based on the contemporary policy executed in the field of public health, a valuable reactive health model is gradually replaced by the prophylactic model of predicting the health status of people, prevention of disease progression and their monitoring. E-medicine technologies, especially IoT, reduce the cost of the overall health system through technological solutions, remote diagnostics, remote monitoring of the patients with chronic illness, and due to the effectiveness of controlling the health status and prophylaxis of widespread diseases [38].

Internet of m-Health (m-IoT). Mobile healthcare industry (m-Health) encompasses the generation, collection and sharing of medical data through mobile and wireless devices.

[17, 36] state that m-health is composed of a mobile computing complex, portable transmitters and communication technology to prodive medical care. *m-IoT* is theoretically based on a new model of healthcare access. In this model, future m-health integrates the *6LoWPAN* into an advanced *4G* network for Internet services. In this case, it is required to pay special attention to the specific aspects of *m-IoTs*, which entail the direct communication with human being in the process of monitoring, diagnosis and treatment. These aspects should be taken into account when developing m-IoTs' architecture for e-medicine and when solving contextual and ecosystem issues.

Ambient Assisted Living (AAL). The IoT technology, which supports the surrounding living environment, offers a platform for providing particular care for elderly and handicapped people. The essence of *AAL* is to provide independent living of the relevant people in their residences through modern technology, especially IoTs. Distant monitoring systems and alarms are designed for notifying about potential hazards as fainting, illness, and so on by sending signals. GPS transmitters installed on smart vehicles allow monitoring of the route of movement of disabled patients, activate the warning system in case of fainting and going beyond the specified territory, and the information panel shows their location. [39] depicts an IoT- and cloud-based open, secure and flexible platform that support the surrounding environment.

Adverse drug reaction (ADR). WHO suggests that adverse drug reaction is harmful to the organism, dangerous, and is not intended in the prescription of the drug in certain doses used by humans for the diagnostic and (or) treatment of the disease as well as correction and modification of physiological functions. Adverse drug reactions may occur: 1) after taking the first drug; 2) as a result of long-term drug therapy; 3) taking together with two or more preparations - in this case, the compatibility of the effects of each drug with certain clinical situation should be evaluated.

[40] proposes an individual system to verify the usefulness of drugs using IoT. Mobile devices identify the drugs through indirectly connected links or barcodes. The usefulness of the drug for the patient is verified through an intelligent pharmaceutical information system, which contains DB (drug description, active ingredients, complications) and knowledge base (rules for detecting allergic or unpleasant reactions of the drug). The system checks the compatibility of the drug with the patient's electron records, especially with the certain allergic profiles of certain medications.

Wearable device access (WDA). Ensuring the perfection of "The Internet of Things" is a complicated issue, since its solution requires the revision of all its components, from the general architectural principles of existing identification technologies constituting the modern Internet, to the network management and human rights protection. Today, a large number of various non-invasive transmitters providing WSN-based medical services have been developed for medical applications. These transmitters are quite promising for providing relevant services in IoT environment.

Wearable devices can present a set of features based on the architectural principles of IoT. This implies the integration of existing transmitters into portable IoT-products. Researchers and developers dealing with the integration issues face with numerous challenges related to the heterogeneous nature of medical transmitters.

In this context, wearable devices require special service called *WDA*. Today, due to this service, many applications based on WSN scenarios have been developed for IoT. Many solutions for the monitoring of physiological condition of human in IoT environment, systematic control over physical activity based on the use of portable and mobile devices such as smartphones, tablets, smartphones, bracelets are now available [41, 42].

Context recognition. One of the ways to increase the effectiveness of IoT applications is the implementation of a context recognition service. The availability of the knowledge about the surrounding environment, its users, as well as the application context (for example, generating the map to represent the current location of the user automatically) support the applications to filter the data and adapt their presentation. The more information the IoT device has, the more information will be automatically accessible to the user.

When collecting contextual data through clinical transmitters, appropriate time and spatial characteristics should be taken into account. If these characteristics do not coincide with the required ones, then additional information may be significant for data reading. The context can also play an important role in determining the security, confidentiality, productivity and capabilities of the networks of transmitters. This field of science is being actively studied [43].

IoTs are estimated to be able to receive more information from web services and nearby physical transmitters and share it with other devices over time. As a result, the accuracy of the data received and decisions made will increase. Future devices are predicted to be "smarter". Depending on the context, the development of context-rich system allows for relevant response to the emerging situation [44].

In order to develop context-rich-medical systems on the IoT network base, the developers, as a rule, require the submission of the context framework proposed by the *Embedded context forecasting*. [45] develops a predictive context framework to provide medical services, and [46] illustrates the use of context prognosis for remote medical monitoring in IoT environment.

Intelligent IoT applications on the e-medicine. Success of IoT depends on the applications that improve the daily life of a person. The requirement for the use of certain applications is the presence of transmitters for the transmission of the relevant data set. IoT applications are software applications or software systems designed to handle specific issues [47].

IoT applications play an important role in e-health and are directly used by users and patients. In addition, they enable tracking and monitoring the health of people working in other areas, including those of specific risks. IoT applications supporting one or more health indicators at the same time are shown below.

Glucose level sensing. Blood sugar monitoring enables detecting blood glucose level and nutrition plan, activity, and the time to take medication [48].

At present, IoT-based health monitoring systems are being successfully implemented. However, modern IoT-based continuous monitoring systems for sugar levels are not numerous and existing systems also have some restrictions. In [49], using IoT, the architecture for glucose level monitoring system is developed. The system provides actual information about the amount of glucose in blood, including body temperature and contextual data (e.g. environmental temperature) in real-time mode in a timely or affordable format to the users (patients and physicians).

The authors of the article [17] offer the configuration for *m-IoT* for non-invasive real-time monitoring of glucose providing IPv6-connectivity with medical service providers (physicians) based on the transmitters mounted on the patient's gadgets.

The article [50] introduces a model for sugar monitoring system based on IoT networks comprising the devices for blood collection and glucose level measurement modules, including mobile phones or computers for data transfer.

Electrocardiogram monitoring (ECG). ECG is one of the methods of simple, palliative and informative diagnostics of heart disease. The method is based on the recording of electrical impulses that occur in the heart and its graphic writing in the form of extensions on the special paper film. ECG reflects numerous variations of the certain parts of heart in the form of extensions [51].

In recent years, various studies have focused on the use of IoT in ECG monitoring. IoT technologies are now thought to be quite promising for the acquisition of maximum amount of information related to the activities of cardiovascular system, including ECG monitoring [41, 52]. The article [53] offers IoT-based system for real-time authentication of heart function. The system records the electrical activity of the heart and sends this data to the data analysis center, which detects ECG errors and evaluates the the patient's condition.

Another article [54] develops a complex of algorithm for practical detection of ECG signals in IoT environment for continuous monitoring of ECG. In [55], IoT-based applications are developed to write and monitor of ECG, to measure heart rate and provide the graphical description of the heart rhythm, and then to send these data to the databases and web servers. ECG collecting devices cover the transmission of data on the frequency of heart attacks and *Arduino* microcontrollers. The software is written in Matlab and C $^{++}$ programming languages in order to process and analyze ECG and download it into the database and Web servers.

A new generation *Nuubo*, offering a wireless and remote platform for heart monitoring, is of great interest. This Spanish company produces, manufactures and sells a portable medical technology portfolio for the diagnosis and rehabilitation of cardiovascular diseases. These tools are based on the ECG wireless remote monitoring platform and incorporate patented biomedical electronic tissue technology (electronic smart tissues), which uses digital technology called ***BlendFix Sensor*** [56].

The advantage of *Nuubo* series transmitters is that they can be installed on a daily basis. Smart *Nuubo* shirt is equipped with special devices that control the vital condition of the patient and his/her movements. The shirt records ECG, transmits the sensed data through wireless network to the server for analysis, where special software can define the abnormal parameters. The transmitters installed in the shirt regularly collect parameters such as heart rate, arterial pressure, and body temperature. Shirt-mounted transmitters use a GPS network for connectivity and ensure recording of people on the move (moving throughout the SP) [56].

Heart rate. The frequency of heart rates is characterized by the number of rates in the same time and measured in bits per minute. The frequency of heart rates is substantially dependent on context, i.e., it increases after physical exercises and can change due to stress, insomnia, illness and drug intake. The frequency of heart rates is also affected by age and genetics. IoT-based ECG monitoring systems incorporate the measurement of heart rate and pulse rate, as well as the diagnostics of multichannel arrhythmias, myocardial infarction, and so forth. In healthy people, the frequency of heart rates and pulse are equal [53, 54].

Blood pressure monitoring. Blood pressure is referred to the Withings in the arterial vessels. The blood pressure in arteries, veins and capillaries differs and is one of the main indicators of the functional status of an organism.

High blood pressure is a risk factor for the development of insidious, cardiovascular, and chronic renal failure, thus, it is important to systematically monitor and check the effects of treatment. At present, there are a large number of different devices, including mobile devices, to measure blood pressure.

The relevance of the problem is that blood pressure-measuring devices and a set of mobile phones supported by Near Field Communication have to be related so that they will make up a part of blood pressure monitoring on IoT networks. Performance of the blood pressure measuring devices depends on the model connecting them with a mobile computing device (for example, *Apple*) which realizes wireless data transmission [57]. The article [58] proposes a device equipped with the apparatus for blood pressure measuring with communication modules for collecting and transmitting blood pressure data in IoT networks. The article [59] offers IoT-based Intelligent Terminal which identifies the location of the portable apparatus for blood pressure monitoring.

Body temperature monitoring. Body temperature monitoring is an integral part of health care. This indicator is a vital parameter for homeostasis support [60].

Traditional method of temperature measurement through mercury thermometers has been recently replaced by more reliable and inexpensive wire and wireless sensor transmitters for the determination of health status. To determine body temperature, the article [17] provides an example of the realization of m-IoT concept, which uses transmitters installed on *TelosB Mote* platform. Another article presents IoT-based architecture for temperature control system [61]. RFID module and body temperature control module are the key components of the system responsible for the temperature recording and its transmission in the system.

Smartphones for the development of IoT Solutions in healthcare. Recently, smartphone-driven transmitters have been developed. This enhances the essence of smartphones in the development of IoT technologies. Various hardware and software products that transform smartphones into a universal health device have been developed [62]. Modern smartphones support a large number of health applications (diagnostic, reference, commentary, analytical, etc.) [36]. Health applications also use numerous wireless transmitters running on algorithms to analyze images [63].

Smartphones include effective diagnostics of asthma, cystic fibrosis, allergic rhinitis, as well as monitoring of vital indicators as heart rate, blood pressure, respiratory rate, and so on [36]. Health applications for smartphones offer solutions that are not too expensive for both the patient and the wide user audience. Today, there is a tendency of using multifunctional applications to interact with several sensor devices as of *ZephyrLIFT* series, while the first health applications were designed to interact with one transmitter.

Applications for geographical location tracking. At present, there is a growing need for solutions that enable each person to track the trajectory of traffic and notify the emergency response service immediately about hazardous situations. Modern mobile devices are equipped with information on their geographical location. For example, *Corvus-Tracker* for *Android* operating system is designed to track users' mobile devices. This application sends information about users' geographic location to the monitoring system server. The system is also capable to send SOS signals to the specified phone numbers. The complementary function of the system is to create a geographic area, run within a given time, combine several users in one group, and visualize the system data for the user [64]. Applications for "smart" items' tracking are also widespread. Thus, applications supporting Global Positioning System (GPS) provides operational information to the relevant medical personnel about the location of the users (including those with special risks, as objects, children, elderly people, mentally handicapped people, etc.) through pre-installed sim-cards.

Nowadays, modern systems providing the identification of real-time location system (RTLS) are available. Actually, GPS is considered to be the most important RTLS. This satellite-connected navigation system is able to find objects anywhere on the Earth in different weather conditions. The basic principle of the system is to determine the geographical location by measuring the time of receipt of synchronized signals from antenna satellite navigation in any point of the Earth and of the space. This feature of the GPS can be used for the identification of the location of medical part of the ambulance, patients, physicians, as well as the staff on SP, and for the acquisition of the information on the location [65].

6.6. Technologies used in health-IoTs

The IoT concept for healthcare is realized through a range of technologies. A brief description of these technologies is shown below.

The instruments that constitute the basis of IoT and allow the integration of physical devices into the digital world include *RFID* technologies and *Wireless Sensor Networks* (WSN).

RFID technologies are based on the use of microcircuits that collect information from the devices mounted on the machine or chips installed on the devices. RFID technology enables the transmission of identifiable information wirelessly to the meters via microchips. RFID meters allow identification, monitoring and control of any object automatically integrated with RFIDs [66–69].

RFID technologies can be used in IoTs to track the movement of staff on SP. By integrating IoT technologies with e-Health solutions, it is possible to assign RFIDs to each staff member on SP and to send data to the center. This allows the staff to access electronic health records, and the sent data is stored on the Health Center database. The physician gets access to health records of a specific person by scanning the RFID tag [69, 70]. RFID tag can register any person on SP or the specific business areas of the platform. This is especially important in extreme situations to get accurate information about people on SP and their location.

WSN or *Ubiquitous Sensor Networks (USN)* constitute a technological basis for the realization of the concept of the Internet of things [72].

Wireless Personal Area Network (WPAN) is a distributed network of unserved miniature electronic devices (sensor nodes) that provides collection of data about external environment parameters and transfer them to the processing center based on retranslating them from node to node. All transmitters are linked with interconnected radio-channels located in the air, water and water surface and inside the body.

Wireless body area network *(WBAN)* is a wireless computer network which is wearable and portable on body. These devices can be mounted and implanted into the body, mounted to the body in certain conditions, or installed in clothing (e.g. in a pocket) and carried items (e.g., in a bag) that people wear in different places. *WBAN* system can use wireless network as a gateway to reach greater distances.

The wearable devices can be interconnected through the Internet via the gateways. Thus, health workers can access the information online regardless of the patient's locattion [73].

Wearable Computer networks are expected to be applied for continuous monitoring and important data recording for the patients suffering from chronic diseases, especially diabetes, asthma and heart attacks.

The sensor networks can be applied in medicine in the follow areas:

1) *monitoring of physiological state of human*: physiological data sensed by the networks can be stored for a long time and may be used in medical research; installed network nodes can track the location of the patient;
2) *monitoring of doctors and patients at hospital*: each patient has a network node that performs a specific task; a node controls the heart rhythm, while the other may record the BP indicator;
3) *drug monitoring at hospitals*: sensor nodes can be integrated with medication; in this case, the inaccurate prescription of drugs can be minimized; patients may have the nodes that determine their allergy and important medicines they need.

6.7. IoT-based medical data transfer technologies

At present, networking combinations with different forms and able to operate from different distances, and requiring different powers open wide possibilities for IoTs. They may include WPAN, WiFi networks, wireless mesh networks, cellular networks, extremely broad-band networks, and satellite-connected networks.

IoTs are grouped into near and remote activity segments. The near business segment mainly covers the devices linked with connection channels through the use of unlicensed radio communication technologies (*Wi-Fi, ZigBee, Bluetooth*) covering 100 meters or fixed as a local area network (LAN), Power Line Communication. The remote activity segment covers the devices connected through cellular networks, unlicensed low-band radio communications technologies (such as *LoRa*, *Sigfox*) or satellite technologies.

IoTs are assembled into two groups for distant and remote data transfer. Today there are various portable devices that support medical sensors to collect data. Most of these devices provide connection at a near distance. This can be a link between nodes or sensor nodes, or a gateway aggregating the data from sensors.

If the data is required to be transmitted to the nearest distance, the device can use a Personal Area Network, as well as wired USB interface presented with wireless data transmission technologies such as *BLE (Bluetooth Low Energy)*, *ZigBee,* and *6LoWPAN*.

LAN can be used when the data is partially transmitted at a far distance (e.g., within a clinic or hospital). Wired local networks are often built on *Ethernet* and optical fiber technologies, while the wireless ones are built on *Wi-Fi* technology. *WiMax, LTE,* etc. are used for the organization of a global network (Wide Area Network, WAN) [74]. Over the past two years, the technology has been developed to connect low-powered devices to *LPWAN* [75].

Data transmission speed and energy consumption are the key factors for the choice of cellular technology in specific cases. *BLE, ZigBee, Z-Wave* are used in limited-powered devices and comprises the use of gateways for data aggregation and sending them in IP-network [4].

IoT uses the BLE and ZigBee technologies for data transfer at a close distance.

Bluetooth LE technologies. *Bluetooth* is a wireless technology that provides the data transmission between the devices that are not too far away from each other. This technology allows the communication between the devices within the coverage of 10 meters. One of the significant advantages of *Bluetooth LE* is its low power consumption and extreme low power consumption in sleep mode. In other words, the device "sleeps" at 99% of the time and “awakes” for a short period of time, shares data and “re-sleeps” again. In general, *BLE* is very advantageous in medical applications. It is safe and has low bandwidth, low latency, low power consumption and resistant to hindrances. This standard is recommended for the design of portable healthcare systems.

Bluetooth 5.0 is the newest generation of *Bluetooth*, allowing for data sharing between devices at a distance of up to 200 meters and at a rate of 4–12 megabytes/s. [76].

Wi-Fi technologies are designed to provide access to wireless broadband networks for high speed data transfer. The networks can be expanded without interlayers and wire through *Wi-Fi*, with access to network and mobile devices. Within the Wi-Fi zone, several users can access the Internet on a computer, laptop, tablet, phone, etc. [77].

ZigBee (6LoWPAN) technologies. *ZigBee* is designed to create WPANs using small-size radio transmitters with little power. *ZigBee* technology is oriented at the applications capable to operate separately and securely for a long time during high-speed data transmission [28, 78, 79]. *ZigBee* is used in bio-transmitters for medical diagnostic devices, medical equipment, and for the monitoring of the condition of athletes, including the personnel operating at high risk sites. In this case the maximum transmission speed accounts for 250kb/s. *ZigBee* consumes low power operating in sleep mode. Devices can be enabled by pressing the button, working with the timer, and so on. “Sleeping” devices switch back to "sleep" mode as soon as the data is transmitted and they get the confirmation on the receipt of the package by the main line. The disadvantage of *ZigBee* technology is often due to the fact that it is not used on smartphones, although *BLE* is used. Therefore, the use of *ZigBee* technologies in fixed locations is recommended.

ANT + technology is a wireless communication standard designed to transmit information between ANT+ supported devices [5]. This standard uses the frequency used by Bluetooth, supports up to 30 meters distance, and is implemented through special chips allowing the data transmission between devices. The standard is intended for house use and medical application. This standard is used by *Philips, Samsung, Sony, HbbTV, France Televisions*. Its main advantages include low energy consumption, thus the ANT+ connection uses 70% less energy than *Bluetooth*.

3G/4G LTE (Long Term Evolution) and 5G technologies. 3G is a third-generation mobile communication technology, providing a set of services combining both high-speed mobile access technologies with data transmission channels, as well as Internet-based services. 3G networks work within the range of decimeters and centimeters, and transmit data at speeds of up to 3.6 mbit/s.

4G LTE is a fourth-generation mobile communication technology, designed for high-speed wireless data transmissions in data-driven mobile devices and other equipment. The objective of 4G LTE is to increase speed and transmission capabilities using modulation methods and digital signal processing, as well as the reconstruction and simplification of IP-based network architecture, which will significantly reduce delays in data transmission in regard to 3G-architecture networks.

5G is the next generation mobile communication technologies, which involves the creation of a network that practically enables connecting almost everything. The transition to global standard 5G NR (*New Radio*) will ensure a new mobile broadband connection for smartphones (tablets) in 2019. These devices sense the information from transmitters in the human body and send them to the network for general use [73, 80].

NFC technologies *(Near Field Communication).* In recent years, near field high-speed wireless technology has also improved significantly and allows data exchange between devices at a distance of about 10 centimeters. NFC technologies were primarily intended for the use on digital mobile devices. This technology is a simple expansion of contactless standards that connect interface smart cards considering it a single device. The NFC device supports the communication with a smart card and other NFC devices which can work with existing contactless card infrastructures [6].

NB-IoT Technologies *(Narrow Band IoT)* is a new generation of cellular connection standards for telemetry devices for low-scale data exchange (2016), designed to connect a wide spectrum of autonomous devices, including medical devices to digital network connections [80]. Since NB-IoT is protected and supports a large number of devices and transmission at a great distance, it is very convenient for healthcare applications.

Transmitters. The development of transmitters is one of the main incentives for the expansion of the ICT application. Transmitters measure the physical data and convert them into raw information. This information is then stored digitally, and useful for analysis and processing. Miniaturization of sensors has allowed them to integrate into "smart" devices, with the latter being able to record data, analyze the data, and allowing them to be transmitted over the Internet.

The size of modern transmitters can range from one millimeter to tens of centimeters. At present, the work is underway to further reduce the dimensions of transmitters to ensure high comfort within the human body.

Transmitters are fastened to the body in a variety of ways, and combined with the basic headset (often with a smartphone) via wireless technology, such as via *Bluetooth, ANT +, ZigBee*, etc. Transmitters have to work perfectly and autonomously for the full realization of IoT capabilities, i.e., transmitters must be systematically fed. Solution of the problem should be sought from the environment: the methods of generating electricity from vibration, light and air flow [82].

Many achievements have already been done in this area. Scientists have announced the utilization of commercial nanogenerators – the chips that transform the movement of the human body (even one finger) into electrical energy, which avoids the use of battery and electrical sockets [83].

IoT platforms. An IoT device is interconnected via the Internet protocols for data transmission between each other. IoT-platforms provide bridge services between sensors and data transmission networks. The most popular companies in the IoT platform market may include:

- Amazon Web Services;
- Microsoft Azure;
- ThingWorx IoT Platform;
- IBM's Watson;
- Cisco IoT Cloud Connect;
- Salesforce IoT Cloud;
- Oracle Integrated Cloud;
- GE Predix.

6.8. IoT and other technologies

The development and use of IoT potential will be possible in its interaction with other technologies. Cloud technologies, Big Data tools and techniques, artificial intelligence technologies should be mentioned here first (figure 6.7).

Figure 6.7. Interaction of IoTs with other technologies in e-medicine [84]

Cloud technologies. The IoT system generates a large amount of data to be stored, processed and shared. Clouds in the universal architecture of IoTs have three main functions:

- data collection and storage (transmitters' indicators), and their accessibility. The devices with transmitters collect giant volumes of data; the latter ones are stored in the clouds for further processing and analysis;
- data analysis. Cloud services provide data review, cross-connections detection, and important data extraction, including transformation of transmitters' indicators for remote data exchange and decision-making. Real-time analytics (analytic processing), including the analytics implemented after packet mode data collection in wide intervals. In this case, machine learning and data acquisition algorithm and technology play an important role;
- providing execution commands: IoT systems refer to data in different directions, along with transmitting the

transmitters' indicators, and ensuring that the commands are securely activated from the cloud.

In addition, cloud solutions perform administrative functions such as managing the records of device and users' logs, performing the protocols of use, monitoring of server status and reporting [85].

Big Data is one of the most important technologies that complements IoT and provides tools and techniques for large, diverse, different sized and unstructured data processing. The use of IoT also increases the number of large data in e-health [86]. Anyone in need of regular medical supervision and wearing a transmitter is the generator of infinite large numbers of digital anamnesis. Thus, one of the most important issues for the development of new medical technologies is the solution of large data generated by IoT transmitters. Modern medical technology allows scanning a body for only a second, whereas the whole human body is scanned for 60 seconds. This means that after appropriate examination, 10 gb of data will be sent to disease archive in the form of unprocessed images and electronic reports. Moreover, the volume of data on the EHR of an adult patient will account for more than 2 TB.

The development of specific analytical tools aimed at working with medical data is very important for the solution of big data problem in medical IoTs. Today *Hitachi Clinical Repository's* solutions are very successful in the market [87], these solutions allow processing the results of the examination and the raw medical data from various sources, and obtaining the necessary information.

Artificial intelligence technologies. Several researchers and developers offer creating "sensitive Internet objects" by transferring artificial intelligence to the "objects" and communications networks. They state that IoT system should have the features of "self-configuration, self-optimization, self-protection and self-healing" in the future [88, 89]. The “smart” things are estimated to be “smarter” due to context dependence, large memory, and extensive processing capabilities, as well as ability to think [90].

The Internet of Things generates a huge amount of data; however, the real problem is the timely and precise processing and analysis of this data. The analytical capabilities of artificial intelligence applications on servers that handle data obtained or served to the IoT networks can provide fast and adaptive data collection. The combination of IoT and artificial intelligence technologies will enable the development of "smart" and "connected" machines to interact with each other and to make decision with the without or minimized participation of a human in general.

6.9. IoT in healthcare: risks and challenges

According to analysts, the most widespread IoT segment in the next five years is estimated to be medicine and healthcare. The key demand factor for this technology is the availability of the direct connection between IoTs and patients in the process of diagnosis and treatment.

However, this factor directly constrains the specific health risks associated with the direct installation of IoT in the human body. Then, the global communication, which enables the collection, processing and automated coordination of large amounts of personal information, requires security and protection, confidentiality of personal information [91–93].

The risks and challenges arising when applying IoT solutions in medicine and posing a threat to both the physical security of the patients and the confidentiality of their personal data are given below:

- The risk of breaking the system that is installed in the human body and transmits the medicines, the insertion of the lethal dose to the system, the un-timely insertion of the medication to the body;
- Attacks on the transmission of vital data on the patient's health condition from monitor to the doctor's cabinet via the network, the risk of system crash and information theft;

- Attacks on personal gadgets (remote interference to pacemakers, diabetes supporting systems, infrared optic lenses, etc.);
- The problem of information security and confidentiality protection due to the mobility and complexity of IoTs;
- The challenges and requirements for the protection of personal information on the Internet arising from the capability of IoTs to track and automatically interconnect a large amount of private and personal information;
- High requirements pet forward to the developers of IoT solutions in healthcare related to the guaranty of security and confidentiality of patients' information (this promotes the increase of the price of IoT products and the decline their accessibility in the market);
- The importance of identifying the research on the security and confidentiality IoT solutions in health care and offering a more robust security model;
- The need for a thorough analysis of the encryption technologies prior to the use of information received from wireless sensor networks or other networks for the protection of information when applying IoTs;
- The uncertainty of information security and confidentiality issues and their legal interpretations in IoT;
- The lack of unique standards and protocols for data transfer that complicates the integration and co-operation of different manufacturers in ICT industry;
- Transition to IPv6 protocol in the development of IoTs and the technological problems associated with energy supply of billions of new transmitters;

- Availability of psychological barriers, such as lack of trust of major clients (patients, doctors and other medical professionals) in machines in critical decision-making;
- Exceeding volume of data (even large-scale data) in IoT solutions database;
- Traditional conservatism of patients and medical professionals, one of the main obstacles to the application of modern technologies.

Thus, the research in this chapter shows that the device of IoT can be viewed as an interconnected physical object and precise mathematical software model. Future IoTs are estimated to actually assure the unification of digital and physical worlds, where applications, services, software and hardware components comprise the elements. At this point, there will be digital analogs capable of receiving information from the surrounding world in each IoT object of the real physical world, and able to mutually communicate with each other. As a result, a completely new cyber-physical environment will be created. The intelligence, which is the basis of applications in such an environment, will allow evaluating the events happening in the physical world and taking into account previously collected data and experience in decision-making [94, 95].

Analysts and experts believe that IoTs will determine the development of all areas of healthcare. Today, IoT technology offers innovations capable to provide physician's care and fundamentally change the disease prevention system. IoT technologies have first been used in the medical field, allowing to collect and process various types of medical data in the 24x7x365 mode, analyze the data sets about them and identify potential threats.

IoTs provide broad opportunities for the development of person-oriented medicine targeted at the needs of the specific patient, and thus, the diagnostics, treatments, operations, logistics of drugs, patient and personnel monitoring technologies, and so forth became available.

The things together are capable of creating the most various systems, for example, to enable a human to work in the most inaccessible and inaccessible environments (oil platforms, coal mines, space, vast depths, nuclear installations, etc.) [5, 96, 97].

The IoT services and the next expansion of the applications will reduce the cost of medical services due to reduced demand for emergency aid, reduced visits to hospitals and reduced time allocated to it. The data sensed by intelligent devices over a certain period of time will allow the staff to provide clinical information to make decisions on building a behavioral model of patients and on the selection of more effective methods and strategies for treatment.

The tendency of gradual decrease in the dimensions of the currently installed devices is estimated to accelerate, and the mobile devices are predicted to be implanted more on human body. In this case, microscopic transmitters implanted inside the body and portable or body-worn devices will allow sensing the objective information about the condition of a person (at any point of the world) and controlling the treatment process. This increases the probability of receiving medical assistance before an unwanted situation occurs.

Today, many countries recognize that IoT has the ability to fundamentally change the world as a whole, separate areas, including medicine. Obviously, many countries and organizations develop the strategies and guidelines on the use of IoT technologies in medical field, and conduct research on its application in different segments of medicine [988].

It should be noted that the use of IoT in the field of health is still at the early stage of development. At this stage, besides the development and growth of medical IoT solutions, it is also necessary to deeply study these technologies and to comprehend consumers' benefits.

Nowadays, the tools that enable the clinicians to benefit from the patients service model based on predictive, prophylactic and individualized medicine.

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CHAPTER 7. E-MEDICINE AND SOCIAL MEDIA

Social media is an Internet technology that generates and distributes information through virtual societies and networks. At present, there are many social media tools available to health professionals. They are network platforms, blogs, micro blogs, wikis, data exchange sites, virtual reality, etc. These tools serve to improve professional networks, to develop public health programs, and to educate patients. Using social media resources, the patients can get information about their health and illness; share their experiences in the treatment of certain illnesses; get information about doctors; consult with doctors and get advice and recommendations; and independently make decisions referring to the medical information.

Social media has also created a wide range of opportunities both for doctors and patients. At present, doctors using social media are able to: watch conferences and consiliums without leaving the workplace; hold discussions with colleagues; provide decision support in clinical situations for nurses; and involve professional staff to raise personal potential.

Thus, these opportunities provided by the social media for the patients and physicians, the integration of e-medicine and social media opportunities, and the work of medical professionals, physicians and patients in social media have shaped different virtual relationships [1]. The systematization and classification of these relationships and analysis of decision support in the relevant segments require comprehensive research.

On the other hand, social media creating these opportunities cause serious threats such as dissemination of false information, spoiling professional image, violating patient and doctor confidentiality, breaking personal and professional relationships, and other similar potential risks. Therefore, it is important to analyze the risk factors of social media in e-health environment.

7.1. Integration of e-medicine and social media opportunities

The concept of "social media" is a term expressing the combination of new social technologies with interactive elements such as multimedia, audio and text. Social media may also be called "Web 2.0" or "social networking". Social media enables each individual to benefit from various services. One of these opportunities is to get the necessary information and valuable materials about people and companies by using social networks, forums, blogs, news and entertainment portals. To access these materials, each person should be identified and register in these sources and upload required information about himself/herself.

Social media can be grouped as follows:

- social networks (*Facebook, MySpace, Google Plus, Twitter*);
- professional networks (*LinkedIn*);
- media sharing networks (*YouTube, Flickr*);
- content production (blogs (*Tumblr, Blogger*) and microblogs (*Twitter*));
- data collection (*Wikipedia*).

Medical social networks. At present, various types of medical networks are available in social media. One of them is *Sermo*, a social networking community for doctors. Comprehensive information about new members is collected during the registration. Members of the network include 68 doctors from 50 states of the US. They discuss treatment methods and consult with experts through the network. The number of doctors in Sermo reached 260,000 in April 2014. Most doctors use pseudonyms to provide anonymity [2].

Doximity is a social networking community for doctors established in March 2011. According to the 2015 report, this network has more than 500,000 members. Doximity is considered to be the most powerful medical network in the United States in 1996, according to the *Health Insurance Portability and Accountability Act (HIPAA)* adopted in the United States [3].

Networks, such as *The Medical Directors Forum, QuantiaMD, Doctors Hangaut, Doc2Doc*, are important platforms for healthcare providers to communicate and collaborate with each other and patients [4].

Student Doctor Network, the US and Canadian famous Internet resource, assists students to get access to higher education, physicians and veterinarians to do internship. This website has 40,000 active members and 1,5 million visitors per month. Social networks *SHP Connect*, *PharmQD*, *The Pharmacist Society* are available for pharmacists [5, 6], whereas social networks AN*ANurseSpace*, *NursingLink* and *SocialRN* bring nurses together.

Blogs. The first blog was created in 2004. The blog is a personal magazine as a website comprising different types of information, ideas, comments, and hyperlinks. At present, blogs are considered as one of the strongest Web 2.0 and new media tools. Being created by *bloggers*, the blogs have a wide audience. Information of great interest is often shared by readers for multiple times. Data is presented in various forms – text, video, audio. *Tumblr*, *WordPress*, *Blogger* are the most widely used blogs [7].

Most doctors use blogs to communicate with other health care professionals or societies. For example, the *Clinical Case* massively brings together medical professionals. Moreover, it includes special sections that contain records and guides. Pharmacists are more interested in blogs.

Microblogs provide information exchange in a more dynamic and brief form via social media over a short period of time. Twitter is the most commonly used microblog. It is used by Twitter in Twitter for real-time discussions and presentations in conferences, exchange of information between students and teachers, and student monitoring [8].

Wikis. Wiki is a public web site. Users may upload and edit text, multimedia, and content here. Wikipedia is widely used in medical society. Although Wikipedia is not a reliable source, most medical professionals use it. Thus, surveys show that 19% of pharmacists do not trust this resource; however 35% of them use it. One of the key features of Wikipedia is its popularity in

Google search engine [9].

Media-sharing websites. Medical-mediated media-sharing websites can be an important resource for teaching, public health awareness, and marketing. Media-sharing website is easy to use, and provides users with free registration and ensures both computer and mobile device access. *Youtube* is the most commonly used media-sharing website. Another media-sharing website for health professionals may include *The Doctors Channel*. The most interesting videos about medical innovation, medical education and health are uploaded here [10].

Professional networks. Establishing a certain social network for each specialty has always been a matter of time. In recent years, the massive use of social networks has led to the development of professional communities. Since 2000, social networks of doctors have begun to function in Western countries. These social networks may include *Sermo (www.sermo.com), Doc2Doc (www.doc2doc.com), Ozmosis (www.ozmosis.com), Healtheva (www.healtheva.com)* [11]. In 2010, more than 700 medical centers in the US created corporate social networks to improve the services delivered to patients, to seek and recruit medical staff, and to sign agreements with pharmaceutical companies and medical technicians [11].

LinkedIn is a professional social networking website with an average of 1.5 million healthcare professionals registered for job search and professional development. It is a useful tool for healthcare professionals to look for work, identify a highly-qualified employee, and learn more about any company or its employees. Health professionals registered in the *LinkedIn* are doctors, providers, researchers, managing staff, pharmacists, and biotech workers and managers [12].

The number of users in social media is rapidly growing. The use of social media in the United States has increased from 8% to 72% in the period from 2005 to 2016. In 2002, the number of *Facebook* users throughout the world exceeded 1 billion. In *Twitter,* 100 million active users send 65 million tweets (messages) per day and two billion video are uploaded on *Youtube*.

The study of various types of social media shows that they are used for the following purposes:

- more rapid access to information;
- establishing contacts with local and remote communities;
- sharing ideas;
- expansion of medical education;
- establishing relationships with people;
- establishing labor relations;
- conducting researches and discussing results;
- searching for job vacancies, etc. [13].

Analysis of social networks identified that 42% of reviews of social media is related to search for healthcare information, 30% – for moral support for patients, 25% - for personal experiences, 20% – for medical forum attendance and community membership.

7.2. Activity of medical professionals in social media

Social media provides medical professionals with necessary tools to share information, hold health policy debates, observe health-related behaviors, communicate with population, patients, their guardians and partner-students, and to be educated. Health professionals use social media to seek information on potentially reducing medical costs, get medical innovation, motivate patients, provide information to citizens, and to be informed about the civic satisfaction with the quality of medical services.

Doctors join online societies to read new articles, listen experts' lectures, conduct medical research, appoint precise diagnosis, and consult with colleagues. Doctors can share ideas and medical experiences, conduct discussions for problem solution, post summaries, discuss and sell research works.

The survey *QuantiaMd* conducted among 4,000 physicians has shown that 90% of doctors use social media for their personal activities, whereas only 65% of them benefit from websites for their professional activities. Social network *"Доктор на работе"* is registered as a specialized scientific-medical mass media to attract experts and shares scientific articles and clinical researches on its website. For example, video section of social network *"Медтусовка"* contains interviews of prominent doctors, video conferences and educational videos.

Thus, doctors receive the necessary information, share their observations on medical issues, treatment methods, experiences related to the modernization of healthcare and make important decisions. In addition, doctors can publish articles free of charge, and earn money and extras [14].

Annual report of the *Manhattan research Taking the Pulse* confirms that only 22% of European doctors used social networks in their activities in 2012, and this figure increased by 13% in the following years. *Bayer Healthcare Chin*a's report for 2009 shows that 97% of physicians from five major cities of China were the members of social networks. This figure in the UK was accounted for 48% [15].

English-language portal *Healthcare IT news* held a survey among doctors, which showed that 87% of doctors used social networks in their activities [16].

Unlike doctors, pharmacists rarely use social media. They are mainly accessing social networking on pharmacy. Surveys show that many pharmacists often use *Facebook*. *Facebook* includes more than 90 pages related to pharmacy. For example, *Pharmacists Interest Page*, the *American Pharmacists Association*, and the *Cynical Pharmacist*. According to the 2011 survey, 38% of pharmaceutical faculty graduates use *Facebook* for education, and only 10% of pharmacists prefer *Twitter*.

Online social media platform assistance for nurses to expand their educational experience. With the use of *Twitter*, 53% of nurses develop their skills to make decisions in clinical situations.

American College of Physicians and the Federation of State Medical Boards initiated a new conceptual document to guide physicians to follow ethical standards while using social media, how to apply professionalism principles online, preserve mutual trust between patient-physician relationships, and take into account the interests of patients [17].

The main provisions in this document contain the followings:

- not to interfere personal life of the patients;
- to be sure of the professional level of shares and comments before they are shared;
- to take into account the probable damage to the reputation of physicians before posting shares and comments online and non-professional shares ;
- to ensure complete data privacy of the patients;
- to divide the content to be shared in social network into personal and professional groups.
- to establish patient-physician relationship and ethic norms in the course of communications, being patient and accurate.
- not to add patients to "friend" list or confirm "friend" request.

7.3. E-patients and social media

In the 90s of the last century, the concept of *Patient 1.0* appeared. Patients used information technology to search for medical information [18].

In 2008, a new term – *Patient 2.0* (E-Patient) emerged. These patients are now using information technology not only for medical information search, but also to share that information in social media [19].

Representatives of *Patient 2.0,* unlike *Patient1.0,* are well informed about the symptoms, schemes, and treatments of illness and concerned about their health and its strengthening methods. Prior to visiting the doctor, *Patient 2.0* is surfing the Internet for their illness, treatment and symptoms. They share their experiences related to the treatment results obtained from these or other doctors, hospitals, medication and treatment deficiencies on social networks [20, 21].

The term E-Patient (*Patient 2.0*) was first offered by Tom Ferguson in 2007, and his article on this problem was published after his death in 2017 [22].

The article recommends the patients to collect information about their personal health from the Internet and share this knowledge with other patients, while the physicians are told to collaborate with patients in the treatment process.

E-patient attempts to get more information and knowledge regarding their own health through the Internet and medical social networks**.** Therefore, e-patient gets an opportunity to participate in the decision-making process concerning the treatments. Today, the concept of "responsible patient", who is able to make independent decisions, is getting popular in the world. Involvement of a citizen in the protection of his/her own health has become an integral part of the policy of a number of states [23]. Thus, the combination of patient-oriented medicine, social media and the Internet has opened a new era in medicine of the 21st century. In recent years, patients have been actively involved in addressing their health problems viewing them as a source of information. They reveal the answers to several questions by referring to the information shared in media regarding patients' attitudes toward these or other medical problems. The phenomenon of obtaining additional information through social media is called "*real world evidence*" in international medical environment. In social media, patients share their personal medical information in groups, discuss them, and are morally supported by those who have previously experienced this disease. In some social networks, patients create platforms called "*data-sharing*" where they share information on their health condition aiming at getting their revenue [24]. Here, patients share information on their own conditions, symptoms of the disease and treatment costs, and the members benefit from this information. This means that doctors and medical professionals get the results of testing and surveys without funding. Furthermore, this type of patient information leads to new clinical trials [25]. For example, as a result of studies conducted on these platforms, the effect of lithium therapy on the development of amyotrophic sclerosis has been revealed, and in the further studies this procedure has begun to be applied.

Most patients use the following social networks and social media platforms: *Smart Patients, Stupidcancering, e-patients.net, Woman Heart Support Community, babycenter, Daily Strength and Facebook, Twitter*.

PatientsLikeMe [26] and *Treato* [27] are supporting only e-patient societies. *PatientsLikeMe* is designed to analyze the types of therapy (including preparations), symptoms, possible complications, and other aspects based on the treatment experience of various diseases. One of the main issues of this resource is finding similar diagnosed patients and creating opportunities for users to examine their treatment experiences. On the other hand, a user is able to monitor his/her own health. The database of the resource represents more than 400,000 members of society, about 2500 cases of illnesses and over 35 million facts. The information presented in the database and the results of their analysis can also be used in research in medicine and pharmacy.

Treato is an automated monitoring tool of leading web sites and portals (social network, forum, etc.). *Treato* data shows that the system has analyzed 2399748414 data about 24748 cases/symptoms and 26616 preparations/treatments thus far. The analysis confirms that the main "scope of interest" is medicines and diseases [28].

The studies show that e-patients are using social media more than traditional patients for searching for medical knowledge.

Table 7.1

The ratio of e-patients and traditional patients using social resources [24]

e-resource	e-patient	ordinary patient
Wikipedia	53%	17%
Using social networks such as *MySpace* or *Facebook*	39%	17%
Using blogs	37%	10%
Creating blogs	13%	4%

E-patients collect health information using various information technology services. Obtained information covers various aspects of medicine. The results of surveys show that e-patients mainly focus on the following medical information [29]:

- 33% – weight gain or loss;
- 27% – health insurance;
- 18% – establishing contacts with other e-patients with similar health problems;
- 12% – regulating the health condition during visits abroad.

7.4. Social media and crowdsourcing

Medical social networks are important online platforms for hundreds of thousands of people to get information about their health, share views, discuss symptoms and treatment methods, make joint decisions, get moral support, and get acquainted with new treatments.

Crowdsourcing is a form of volunteer co-operation through a large number of people on the Internet with their potential (knowledge, experience, ideas, services, etc.) to solve any problem [30]. The essence of crowdsourcing is that the results achieved together with the knowledge of thousands of initiatives (collective intellectuals) are much better than of those produced by one or couple of experts.

In the social networking environment, crowdsourcing technology can be effective in diagnosing the patients with rare diseases. Thus, crowdsourcing provides accessibility of knowledge, judgments and specific experience of thousands of people (including those with severe diseases and cured patients, former and practicing physicians, practitioners, and persons with independent medical knowledge) in the social media for the solution of various medical problems or projects.

Doctors can get information about alternative diagnostic options and their probabilities for the treatment of a complicated disease using crowdsourcing**.**

E-patients can assist doctors in obtaining the necessary medical data and similar case studies. Hence, this type of patient shares the symptoms, demographic indicators, or the relevant parts of their health care card on the social network and accesses a "wise collective decision" made by experts and cured patients on the diagnosis and treatment of the disease.

Webicina, for example, is one of the social networks using crowdsourcing services [31]. It contains sections for patients and professionals and each patient can get reliable recommendations and medical information from this resource.

7.5. Social media benefits in e-medicine

Despite technical advances, physicians are always overloaded with patient appointments and reports. They often do not have enough time to use scientific and medical libraries, read scientific articles on their specialty, conduct professional discussions with more experienced colleagues, argue about effective treatments of various diseases, and get information about new medical diagnostics equipment, new perspectives and adverse reactions of medications [32].

Social media solves all above mentioned problems. Physicians can organize consilium without leaving work place, discuss clinical situations with experienced colleagues, get recommendations, watch interesting speeches at scientific conferences and seek job vacancies.

For physicians, social media is a powerful tool for sharing, collecting and editing information amongst participants. Moreover, it is a strong source for advancement in career and influencing the audience entirely.

In addition, medical institutions also benefit from social media. Thus, social media is the most comfortable Internet site for medical institutions to search and recruit medical staff. At the same time, social networking resources allow healthcare providers to promote the medical institution.

One of the possibilities of social media is its use for the development of education, especially in establishment of academic libraries and virtual classes, and hiring students.

7.6. Risk factors of social media in e-medicine

Along with the advantages of social networks, they have risk factors that can undermine their potential too.

First, some resources have a long registration process. For example, social network "*Доктор на работе*" consists of health professionals. Its registration requires uploading a job address, information about the educational institution, diploma number and copy. Facing such difficulty, doctors interrupt the registration process. Even the popular American social network *Sermo* requires the specification of specialty, address of educational institution, address of workplace, and identification number of professional activity.

One of the major threats to social media is the misrepresentation of the content, the poor quality of content uploaded by non-professional users in real-time mode, and low-level and non-professional debates.

In social media websites, the authors of medical information are mostly unrecognized doctors with limited facts. In addition, medical information is sometimes unreliable, incomplete and informal. This forces highly qualified specialists to leave the social network. At the same time, there are doubts about whether the information is accurate or up-to-date, which decreases the number of users [33].

Therefore, health care professionals recommend patients to access more reliable sites to get better quality information. The WHO recommends using the Internet Corporation for Assigned Names and Number, which guarantees the reliability of all medical information. Web sites with similar domains are constantly checked and ensured to meet the required criteria [34].

One of the reasons undermining the power of social media is the threat of dissemination of personal data of patients. The violation of personal confidentiality of physicians during online communication is also referred to social media threats. Thus, patients can send physicians a friendly request on *Facebook*, though most physicians do not accept this friendship to prevent their privacy. Instead, health professionals offer the patients developing a website. For example, the portal *Caring Bridge* is a non-profit resource, where mass medical information is provided for patients and their privacy is protected. Patients can easily interact with doctors via *Caring Bridge* [35].

The attitude of a manager of medical institution to its employee may vary depending on his/her profile on the social network, shares, recommendations and comments. Thus, social networks require doctors to utterly follow ethical norms and behavior standards. It is advisable to be sufficiently cautious and attentive during the discussion.

Social media has already become a successful business in the field of e-medicine. Business relations of social media are largely shaped due to collaboration with pharmaceutical companies and medical equipment manufacturers. The risk factors in this segment are often observed in the violation of legal norms.

In depth research on the prevention of the listed risk factors is conditioned by the rapid growth and expansion of social networks and regulated within rules and norms specified and coordinated by relevant health care institutions and organizations [19].

7.7. Social relations in e-medicine

Study of various types of medical social media resources allows identifying their trends and main scopes (users). This, in turn, has resulted in the segmentation of users by their scopes and the development of certain types of requests and relationships in the virtual space. Depending on these relationships and requests type, scenarios for decision-making can be set in the social media environment. As a result of the research, we have found the following relationships in medical social media (figure 7.1):

• ***Physician – Physician relations***. Using social media, physicians can discuss effective treatment methods of various diseases with their colleagues, provide professional advice on clinical situations, conduct scientific negotiations, develop their medical knowledge, and make accurate decisions in clinical situations. Simultaneously, physicians can watch real-time scientific workshops of more experienced professionals, their surgical operations and instructions.

• ***Physician – patient relations***. Physicians use social media to communicate with patients, observe their health, give advises and monitor them. Preserving ethical norms in physician-patient relationships, taking into consideration the interests of the patient is one of the basic requirements.

• ***Patient – patient relations***. Patients use social networks, mostly in search of the following information [31]:

- ✓ diseases, symptoms, diagnosis and treatment;
- ✓ medicines, their use, and adverse reactions;
- ✓ opinions of other patients about doctors and their treatment methods;
- ✓ information about medical centers;
- ✓ finding an identical diagnosed patient, sharing experience in combating certain illness;
- ✓ new approach to treatment and high-tech medical care;
- ✓ use and contraindications of traditional treatment methods and techniques;
- ✓ psychological problems, depression and moral support;
- ✓ information on diet;
- ✓ online consultations with physicians and pharmacists;
- ✓ online purchase of medicines, etc.

• ***Physician – pharmaceutical company relations***. Physicians get information about the medications produced by pharmaceutical companies through social media and get acquainted with their instructions and adverse reactions. Accordingly, doctors prescribe new therapeutic treatments, share information on social media about the poor quality of certain medicines, and call pharmacists to stop producing these drugs.

• ***Pharmacist-advertising company relations***. Social media provide successful business opportunities for pharmacology. Thus, pharmacists contract advertising companies, promote and sell medications in social media, and correspondingly, advertising companies also benefit from this joint venture.

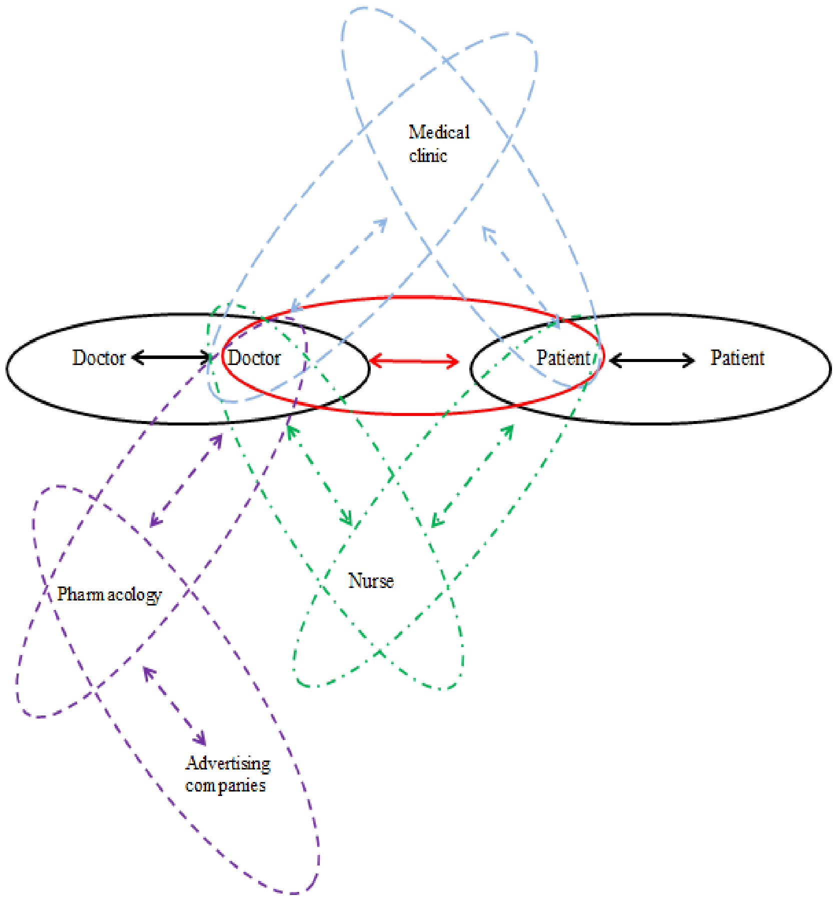

Figure 7.1. Relationships in medical social media

• ***Physician – patient – nurse relations***. The therapeutic process depends largely on the relationship between physicians and nurses. The absence of mutual understanding and harmony in these relationships diminishes the quality of medical services. The emergence of social media has also brought innovations to the relations. Thus, online social technologies such as e-mail and computerized order have enabled physicians and nurses to communicate without interruptions, monitor the patient's treatment, and get information and follow doctors' instructions. At the same time, relationship between the patient and the nurse is also important. The nurse constantly provides moral support to chronic patients in social networks. This improves the emotional condition of the patients and thereby positively affects the course of treatment. Social media has a wide range of possibilities particularly for establishing such relations with the patients with hazardous health problems.

• ***Physician – medical clinics relations.*** Social media has a fundamental role in these relations. Hence, social media is the most comfortable way to search and select medical staff for medical institutions. Managers of medical institutions get information about doctors visiting their pages on popular social networks (e.g. *Facebook*) or personal medical sites to identify the extent of their professionalism based on opinions of patients about their treatment methods, treatment results and experiences. Thus, social media plays a fundamental role for both subjects of the medical-clinical relationship.

• ***Patient – medical clinics relations***. Social media has created many advantages for patients. Using social media sites, patients can access the clinic, its address, contacts and detailed information about medical staff and appointment rules, including the web site of that clinic

Conducted analysis showed that social media became an important factor in the development of healthcare system, and over time, it would be more influential in the activities of doctors, patients and healthcare providers. In social media, the number of communicator-users grows steadily and their forms of activity vary. From this point of view, new virtual relations are being shaped. This chapter classified them as the relations between physician-physician, physician-patient, patient-patient, nurse-physician, nurse-patient, medical clinic-physician, patient-medical clinic, etc. Depending on these relations and possible requests in certain relations segment, the scenarios of decision making in the social media environment are formed.

When using social media, content distortion, real-time upload of poor quality content by non-professional users, conducting low-level and non-professional debates, disseminating personal information of patients and physicians, violating ethical norms and behavioral standards in the specified relationships undeniably cause the emergence of risk factors. This chapter substantiated the importance of developing appropriate rules and norms for prevention of such risk factors and establishing specialized health care organizations.

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CHAPTER 8. IMPACT OF SOCIAL MEDIA ON THE INTEGRATION OF DISABLED PEOPLE TO MODERN SOCIETY

The emergence of the concept of "social media" depends on new *Web 2.0*-based technologies (*RSS*, blogs, etc.) and the Internet resources (online social networking, video-calling, etc.). At first glance, these two concepts differ from each other; however, their feature in common is that they simplify the information sharing among the users. At present, social media plays an exceptional role in regulating online processes. Although, it has been widely used, it is a challenging task to give a full definition of this tool. Kaplan A. and Haenlein M. define the social media as Internet-based software based on the ideological and technical rules of *Web2.0*, and these systems should enable the generation and exchange of user data [1]. For ordinary citizens, this is "a system that helps to communicate effectively with others." Apparently, social media has different meanings for everyone.

Developing social media has created opportunities for people to access information, message, find a job, and review and download various types of media content (photos, videos, music) [2, 3].

The users of these systems have the opportunity to create their own databases, publish them, share them with friends and communicate in real-time anywhere. Social media, i.e., social networks, have created a completely new tradition and have become one of the most important components of socialization. This fact can be observed in changing lifestyle of people and in different aspects of their activities. For example, people now communicate with each other over these networks, show their opinions on social and political issues, and share their achievements. These networks are also used to provide certain services, to conduct online meetings in companies, to obtain different content and to regulate the recruitment process.

However, lack of equal access to social networks leads to the discrimination of people and the creation of social barriers between them and the society, and the emergence of the digital inequality. Although social media is rapidly becoming popular, not all people can benefit from it. As a result, two layers have been created: those who can use it and those, who can not. The isolation of the people with limited health capabilities does not allow them to access information, enrich their knowledge or integrate into society. A person with limited health capabilities is a person who has a full or partial loss of vision, hearing, feelings and with limited movement, and cognitive disorders. These restrictions have a different effect on the way people access the computer and the social media.

When designing the social media platforms, the access of disabled people to these systems is not fully taken into account. Although their use of the network should be regarded as investment in improving the socio-economic situation of the society rather than the expenses for companies and governments.

This chapter aims at examining the use of social networking for people with limited health capabilities and the role and importance of social media in their integration into society.

8.1. Purposes of using social media and requirements of disabled people

The WHO reports that currently, 15 to 16 percent of the world's population has certain health restrictions. This is about 1 billion people [4]. In the corresponding report by the UN, this figure is slightly less and accounts for 10 percent [5]. At present, disabled people constitute 5.6 percent of the total population of Azerbaijan [6]. The studies conducted by the United Nations Development Program have shown that 80 percent of the world population is in developing countries, and 20 percent of the poor in the world are disabled people [7]. Disabled people often have great potential and ability to work actively in the social life, however, the lack of access to information and communication prevents them to realize it.

A number of goals, needs and communication problems of people with limited health capabilities can be solved through the social media. Of course, from the prism of the social media, the social needs of the people with disabilities are directly related to their demographic (age, gender), physical and mental characteristics, education level, work ability and other indicators, which can be satisfied by various means. The goals and needs of the disabled people related to the use of social media are shown below [8–13].

Personal. These goals and requirements imply the communication with other people (written or verbal), exchange of ideas, pictures, paintings, articles and Internet resources.

Job Search and Labor Activity. Social Networks are a new tool for finding a job and establishing contact with the employer. *LinkedIn.com* is intended for creating new business relationships and finding a job. Currently, vacancy databases of social networks offer the jobs to be performed at home via the Internet. Social networks provide disabled people with access to different information, communication, education and work in different areas. For example, positions related to the information technology as a computer operator, webmasters, network administrator, and designer are more convenient for these people.

Education: Finding adequate employment depends on the availability of relevant knowledge and qualifications of the disabled people. The experience of Norway, the Netherlands, Finland and other developed countries shows that the remote education process can be achieved only through the use of advanced ICT. ICT provides an opportunity for the practitioner to communicate with a disabled person. The following opportunities are achieved through the social networks:

1) dissemination of information on participation in online classes;
2) uploading the information facilitating the acquisition of the material;
3) favorable conditions for discussing topics related to the course;
4) opportunities for listening to audio and video lessons.

Leisure. People with physical limitations can use the social network to watch and download entertaining videos, movies, pictures and museum exhibits, play online games, listen to songs in different genres, and watch educational videos. Today, the Internet resources available to people with disabilities provide the sharing of information and innovations between them.

Different services. People with disabilities get access to medical, legal, e-commerce and other services through the social networks. The development of different types of social media (social networks, forums, and blogs) has led to the formation of networks of professional communities. For example, specialized medical social networks bring together the doctors of different areas. These networks allow individuals with physical disabilities to take advantage of online consultations of physicians and pharmacists.

In general, the above-mentioned social media opportunities are very important for each individual, however, the people with limited health need these services more. Of course, support for people with limited health capabilities through ICT and choosing the appropriate technologies can be identified after the reasons for disability are properly analyzed. From this point of view, it is desirable to divide the disabled into four main categories and determine the direction of social integration on each of them [14]:

• people who do not partially or completely see;
• people who do not partially or completely hear;
• people with physical disabilities;
• people with mental problems.

An analysis of the use of social media by disabled people in the listed categories indicates that each category has different purposes for using social media.

For example, the blind can communicate with friends using social networks (*Twitter, Facebook*) and share certain information about themselves. Visually impaired people look for jobs or expand their careers through *LinkedIn*. That is, these systems are really of great importance to increase the well-being of people with limited health capabilities [15].

Studies have shown that disabled people with intellectual disabilities have difficulty to communicate face-to-face with other people. Communicating with others on the Internet and social networks may eliminate this problem. As a result, they can comfortably communicate with others.

There is one thing in common in the use of social media. Thus, social media plays a major role in integrating these individuals into society, regardless of the purpose of use of those with limited health capabilities.

8.2. Technology for using social media for people with limited health capabilities

Modern scientific and technical development creates opportunities for people with disabilities to have equal opportunities in society with healthy people. Given the physical limitations of this category of people, technologies have been created that enable the control of computer hardware, data entry and processing, and software compatibility with certain systems. These technologies, which were first introduced to people with disabilities in 1998, were called "assistive technologies", and a great deal of work was done in this direction [16]. Assistive technologies are a common term that incorporates auxiliary, adaptive and rehabilitation devices [17]. Auxiliary devices are intended for people with all physical and mental defects, while adaptive devices are designed for the needs of certain individuals based on special order.

The following two issues are crucial for the people with disabilities to take full advantage of social media [12]:

- A device or tool used by them should incorporate the potential of certain assistive technology;
- A social media platform or service should be designed to be accessible to those individuals.

8.3. Opportunities to use social media on existing devices

One of the factors influencing the effective use of people with disabilities is that the provision of their access to these technologies and resources.

There are a number of technological tools that support the access of persons with disabilities to social media [16]:

1. Mobile devices. The role of such devices in society is increasing day by day. Particularly, in recent years, everyone has already started using smartphones. The number of people using mobile devices in 2015 is estimated at 4 billion. This indicator is predicted to reach 5 billion in 2019 [18]. Mobile devices play a crucial role in supporting people with limited health capabilities. This is due to the development of certain assistive functions on those devices for the disabled.

A large number of applications on *iPhone*, *Samsung*, *Nexus* and other technology have been introduced. These apps help people with disabilities access the device. They include:

VoiceOver. This application enables the blind people to use *iPhone*. The name of the program automatically sounds whenever the user touches anywhere on the phone. Moreover, if the user receives a message, the device converts it into audio-information. Thus, the user is able to use the phone even if he/she does not see it [19].

Zoom. This application zooms in any object on the screen. Hence, people with a weak vision can use the phone capabilities [20].

Siri. It can be controlled by the voice of the user [21].

Voice Access. It also enables to control the device by voice on *Android* platform [22].

Large Text. Makes it easier to see the texts enhancing all written information on the screen [23].

Apparently, the use of these applications can expand the access to social media.

2. Internet and modern web technologies. Internet and web technologies play an important role in meeting the health needs of people with disabilities. This technology is the basis for social networks and provides the socialization of the individuals with disabilities and their access to diversity of services (distance learning, online education, e-health, etc.).

Modern approaches in this field aim at recovering the social status of the persons with disabilities, achieving their financial independence and social adaptation. The use of social services (market, restaurant, cinema, post office, school etc.) by the physically disabled people is often very difficult compared to healthy people. The use of transport, rent, property, banking and other services and infrastructures, leisure and social activities are also challenging for persons with disabilities. The barriers facing these people can be grouped as follows: physical isolation; labor restrictions; disadvantaged due to the social and labor restrictions; environmental barrier; information barrier; emotional barrier, and communication barrier.

The Internet and modern web technologies are helping the disabled people to overcome these obstacles. Purchase and delivery of the goods from the Internet store, payment of utility services through Internet-banking, and purchase of newspaper and magazines through the Internet-library enables the socialization of these people. Being aware of the events happening around the world via the Internet, taking virtual tours to different cities of the planet or virtual excursions to the museums are also possible [24].

Most of the current events taking place around the world are reported through social networks. It helps the users to access information more easily. In this regard, an active participation of the people with certain restrictions in social networks is directly related to their socialization in the society.

3. Artificial intelligence technologies. One of the most evolving spheres of recent times is related to artificial intelligence. Of course, the problems the people with physical limitations encounter when using social media may not stay out of the scope of this field.

One of the applications used to help the disabled people is *Mind Machine Interface (MMI)* or *Brain-Computer Interface*

(BCI). This app supports the people to control the robots with the thoughts. People who have physical restrictions can use social media more conveniently through these devices.

The studies conducted by the Massachusetts Institute of Technology in 2016 have led to the development of a new technology to help the people with hearing impairments reach out to other people. Hence, the person with hearing problems is wearing the gloves that can transmit information to the computer via *Bluetooth* and conveys this thoughts expressed by the gestures into the computer. The computer helps to understand that person better by converting this information into a voice. Apparently, in the future, this invention can play a very important role in the process of integrating people with hearing impairments [25]. This technology can also be used to integrate people with disabilities into social networks. Thus, large companies, such as *Facebook*, enable their software to be operated with human voice, and people can benefit from this network by using this voice converter device.

Facebook, one of the world's most powerful social networks, has made enough innovations in this area. The company has made use of artificial intelligence technologies to ensure its users to make better and more efficient use of *Facebook*. Thus, the company has provided a voice explanation of the images uploaded into the system through artificial intelligence components to provide the users with vision problems to better understand the images shared by some friends [26]. Through this change, the user with visual problems will be able to see his/her friend relaxing on the shore, playing the musical instrument, or eating with family. It should be noted that *Facebook* supports this app in 20 languages and on *Android*, *iOS* and web environment.

It should be noted that certain work is also carried out in this area in Azerbaijan. For example, the Azerbaijani *NeyroTex* Company has developed the first pilot mini-computer controlled by the voice for blind and visually impaired people with the support of the Ministry of Transport, Communication and High Technologies and the Heydar Aliyev Foundation. The goal is to provide equal access to ICT for blind and visually impaired people.

The new device differs from the others for the absence of a monitor and keyboard, and all commands are controlled by a microphone. The mini-computer is equipped with the capabilities to get acquainted with the latest developments online through the voice commands, to use e-mail, to sound electronic texts, to accept and respond to phone calls. Computer software and all commands are in the Azerbaijani language. The speech translation into Russian and English is also scheduled in the future [27].

Today, people with physical disabilities can read, write, visit, or even get acquainted with surroundings through ICT. Therefore, the catalysts role of ICT in this assistance process will always be important. All these technologies, of course, create favorable conditions for persons with disabilities to use social media.

8.4. Opportunities of software applications supporting social media

Today, social networking provides a variety of opportunities for physically restricted people to use social media. One of the best providers of these opportunities is *Facebook*. It should be noted that people with limited health capabilities may encounter certain questions when using these networks:

- What are the benefits of the software?
- How to install it?
- Where and how to apply if any problem arises?

For a complete clarification of these questions, each network should provide specific guidelines for its physically disabled users and ensure that their use of the system.

There are social media applications that are currently actively used in Azerbaijan. Here are some examples:

Facebook - according to statistics, currently 1.79 billion people worldwide are actively using this social network [28]. The corresponding indicator in Azerbaijan is 1 million 846 thousand people [29]. This network is designed to communicate with more friends, to create a group, to be informed about the opportunities provided by the companies. Obviously, this company, which has the largest market share in the world, is a social network that provides the most accessible opportunities for people with disabilities. Its page titled *Facebook Accessibility* publishes the updates related to the people with disabilities and offers new job opportunities for them [26]. The company has also developed guidelines for them. Additionally, the *Facebook Add Captions* project also offers new opportunities for the people with disabilities. This project provides the users with hearing problems to add subtitles to the videos shared on *Facebook* expanding their opportunities to understand videos [26].

LinkedIn - one of the most important software applications, though it does not have a large share in the social networking market. This network offers its users the opportunity to expand their careers and find new job opportunities. *LinkedIn* is of great importance for the people with health disabilities. Using this network they can find new jobs and even develop their careers. The network has 450 million users worldwide [30]. 143,000 of them are the users from Azerbaijan [31]. Figure 8.1 shows the growth dynamics of *LinkedIn* users for years 2009-2016.

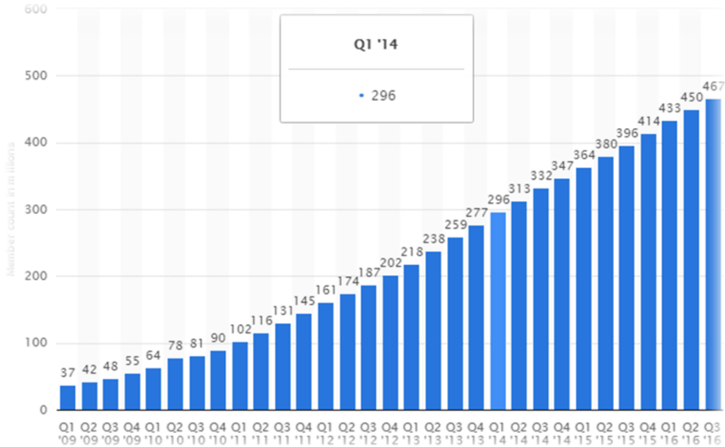

Figure 8.1. The growth dynamics of the users of LinkedIn for years 2009-2016 [30]

Instagram is providing to share the images of the network users. Designed rather for entertainment, this software can be used to help people with disabilities to benefit from more enjoyable and exciting moments. 500 million people worldwide are actively using *Instagram* [32]. In Azerbaijan, this number is about a million [33]. Although *Instagram* is very actively used in the world, it has made few innovations in this area. It just created the *disability hashtag*. The users share their information gathering under this *tag*. Undoubtedly, ignorance of *Instagram* toward such a large user market can lead to lose the competition with other major social networking companies.

Figure 8.2 presents statistical data on the number of active users (million) in various social networks in 2017.

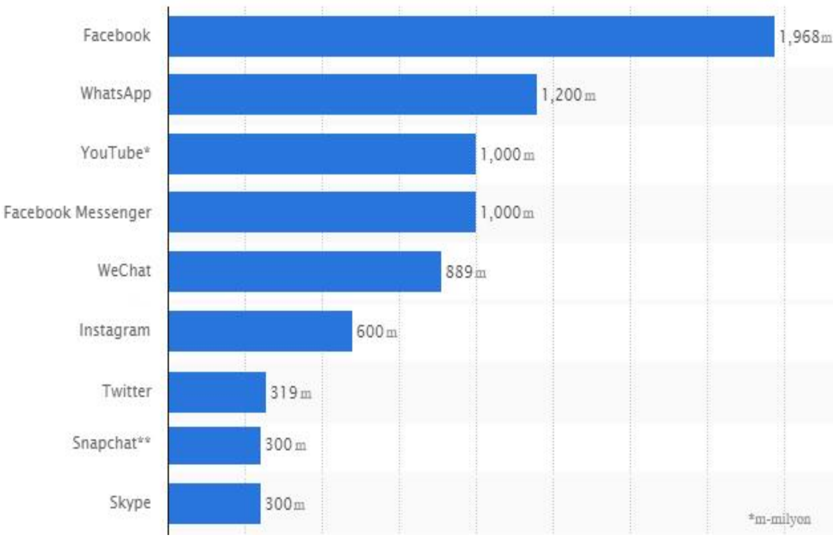

Figure 8.2. Number of active users in different social networks in 2017 (mln.) [34]

Skype – since it is used by both individual users and companies, it is crucial to increase the capabilities of disabled people to use this network. Being used by around 300 million people in the world, this software is also very popular in Azerbaijan [34]. *Skype* has also made a number of changes in this area and has increased the level of accessibility for the people with disabilities. For example, *Skype screen readers*, designed for *Windows 8*, have made it easier for people with visual impairments to use the system [35].

Despite the fact that these social networks have a very important position in the world, their wide and comprehensive use by the disabled people has not yet been fully met. From this point of view, these companies have a great responsibility. With their help, the social media barrier to the disabled can be easily overcome.

8.5. Problems faced by physically restricted people when using social media

The above social networks can meet a number of needs of the people with limited health capabilities. However, not all disabled people can benefit from these resources. Thus, some of them do not have access to social networks, others do not use them for a variety of reasons, while some are even unaware of the existence of these resources.

Obviously, anyone who uses social media must first have access to the Internet. In order to ensure the use of social media by disabled people, first of all, this area should be thoroughly studied. The report of the Pew Research Center for 2015 revealed that only 54% of people with disabilities had access to the Internet [36]. This, in turn, proves that there are still many problems in this direction.

Another problem facing people with disabilities is that both existing devices and social media platforms can not be used by those individuals. This problem has been still remained unsolved, though many companies offer some solutions in this regard. One of the main reasons preventing the use of social media by people with disabilities is the high cost of the technologies providing the access to these resources. The majority of the people with disabilities are unaware of the opportunities created by the government and companies for them. Thus, the problem of educating the people with limited health capabilities and organizing certain training courses for them arises.

The following suggestions are made to address the above-mentioned problems:

1. Provision of the use of ICT of the people with disabilities in each country shall be the basis for the social and economic integration of the citizens of this category.
2. Studies shall be conducted in order to determine the status of the Internet access and the use of social media by the people with disabilities.
3. ICT applications from existing technical tools for the people with limited health capabilities shall be developed and reasonable prices for them shall be offered to expand the access to these technologies.
4. Government shall play an important role in developing, stimulating and promoting ICT applications, and achieving affordability of these assistive technologies.
5. Individuals with limited physical capacities shall be regularly enlightened about the opportunities created by governments and companies being notified through media, social networking, online lectures, and presentations.

As a result of the widespread use of web technologies in recent years, social media has become a very important tool in the community. For the people without disabilities, this sector implies the opportunity to find new job opportunities, socialize, entertain, and learn about certain services, while for the people with disabilities it is a chance to integrate into society breaking down the barriers. From this point of view, the use of this system is of great importance for the people with disabilities. *Facebook, Instagram, LinkedIn* and *Skype* have a large share in the social media area. Though they have some integration efforts in this area, unfortunately they have not achieved the full resolution of the problem. In the modern era, when the social media becomes one of the key components of the society, the access to these resources is one of the most important steps towards integrating the people with disabilities into the society. Government, private companies and civil society should unite their efforts for improving the needs of these people with the needs of the disabled and developing new ICT applications. They should contribute to the realization of the mission of providing the equal ICT opportunities for each individual.

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CHARTER 9. FORMATION OF HUMAN RESOURCES FOR E-MEDICINE: INTERNATIONAL EXPERIENCE, SOLUTIONS AND PERSPECTIVES

The dynamic development and comprehensive application of ICT in all spheres of activity has led to the fundamental changes in these spheres. Consequently, all of these spheres of activity, their structures, forms and methods, development trends have undergone a serious transformation [1–3].

The formation of e-health is a good example. The development of ICT in the world has left the traditional services of health care system behind. Now, the MIS and EHR developed with the growth of ICT are used to support continuous medical assistance in separate MIs and regions [4]. These systems serve as the tools to support decision-making of geographically distributed users, doctors and the patients. They provide the accessibility of the knowledge base obtained from the clinical practice, and also increase the productivity and quality of the healthcare. Such systems enable everyone to get important information in the right place at the right time, which is very important for handling the situation by providing the necessary assistance in unpleasant situations.

The countries with advanced e-healthcare mainly focus on the creation of suitable infrastructure (e-health) to provide better services to the enterprises, regions, and people connected to the health information system and network. Since the health information systems become common in the healthcare system and the traditional medical record keeping is replaced by the information systems and data analytics, the nature of the service provided to the patients is also changing. This is putting forward new demands on the performance of the highly qualified staff in the health care system, and at the same time, requires the integration of the experts in computer science into the health system.

9.1. Challenges to the formation of human resources in e-medicine

According to the experience of the national schools, which have achieved successful results in this field, the whole world has already realized that a key component of the integration of ICT in medicine is the human resources with necessary skills and knowledge. This need has been first reflected in the UK health programs [5], and then Australia and Canada began to focus on the development of the workforce of e-medicine [6, 7]. Health Information Technology for Economic and Clinical Health (HITECH) adopted in the US, which provides “constructive use” of the EHR system, emphasizes investing in the labor force [8]. Currently, it is of particular importance to develop human resource in e-medicine, and to design a data management support system, which collects medical data with high quality, and to train IT specialists to be in charge of the necessary technical equipment. Through e-Health, an infrastructure has been introduced as a tool connecting the world; this infrastructure cannot be realized without the specialists in health informatics [9, 10]. Continuously generating health data and data sets cannot be managed, used and applied without the skills and professionalism required in this area. As the implementation of the national e-Health requires the specialists with the specific skills, they should also have ICT knowledge. Along with the deep understanding of the healthcare system, these professionals must have the knowledge in:

- reengineering and project management;
- health data collection, security and confidentiality;
- human factor and technological processes;
- technologies and supporting mechanisms providing access to the information systems [11].

The development of human resource strategy to meet the healthcare demands is challenging.

On the other hand, along with IT knowledge, the medical IT professionals should also have knowledge in medicine, business and management. According to 88% of IT Directors of 91 institutions providing information services, they believe that the comprehension of healthcare system and the essence of the medical data is the major factor for the successful operation of IT practitioners working in the medical institutions [12]. Thus, this article explores the experience of the countries in training the specialists in the field of health informatics, in which successful results in e-Health formation have been attained. The article analyzes the attempts made in the "road map" of these achievements for the human resources development in medicine. Grounding on the international practice, the recommendations on the formation of human resources in e-health in Azerbaijan are put forward.

9.2. E-medicine human resource challenges

The strategy for the training of human resources in e-medicine is important for health data collection, security and confidentiality, and for the high-quality use of the system and data in the future [4]. To achieve the final results based on EHR, the employees must correctly use and manage the health data contained there. These employees are:

- specialists in health informatics or health informaticians (HI);
- health information managers (HIM);
- specialists with ICT skills and the knowledge in confidentiality and security of health records; human factor and technological processes; project management and technology application; experts capable to interoperate the user-server platforms and being aware of health care systems and data standards.

The workers undertake the task to promote the health care system with the use of ICT. The development of human resources strategy for e-Health is very difficult. Because, the traditional supply and demand models used for the qualification and distribution of the doctors, nurses and other medical workers should include these innovations. To meet the demand for health informaticians, the UK and Australia adopted a national strategy, in 2002 and 2003, and later in 2009 [13–15].

The UK National Health Service allocated £ 12.4 billion for a 10-year national IT program to improve the safety and quality of medical care, and to realize e-Health and EHR system [16]. The program states that “the lack of qualified human resources is a serious obstacle to the realization of e-Health”, thus, there is a high demand for skilled medical workers, but supply is very low. The UK National Health Service proves that “the lack of workforce with the experience in IT applications and medical knowledge is a real obstacle to the realization of the medical project.”

[17] notes that, in Canada, for the realization of e-Health resources, at least $ 7–10 billion are required, as the result of which 9000 health informaticians should be trained. The lack of IT resources is affecting the development pace of the projects realized in the field health care informatization in an entire country. Although financial support for the e-health projects has increased, the qualified human resources have not been supplied, and the shortage of professional health informaticians still remains “a serious risk for achieving a success in EHR initiatives” [18, 19]. [18] states that Canadian Health Informatics Association, Canadian Association for Health Information Management, the Health Sector of the Canadian Association for Information Technologies, Canadian Infoway health structure and the Canadian Board of information and communications technologies started a joint research on defining the experts in national health informatics and health informatics management and on counting their number in e-Health.

The US Altarum Institute offers 3-point evaluation in order to define the demand for human resources for the establishment of a national health information network within 5 years [20]:

1. complete introduction and operation of EHR system in hospitals;
2. complete introduction and operation of EHR system in hospitals and other medical facilities;
3. availability of medical IT professionals necessary for the creation of medical infrastructure, which provides

the inclusion of health records from various sources in EHR and the access of each doctor and patient to EHR, more precisely, which ensures the relationship between all the systems.

It is estimated that 400 000 physicians are required for practical use, and 7600 more specialists – for the complete operation of EHR system, and 28 600 experts – for about 4 000 hospital that need EHR system, and finally, 420 professionals are required for the installation of health information infrastructure [20]. These figures made the history, as the first quantitative indicators for the assessment of the demand for human resources to establish the national health information network.

The databases of health information management service centers of the 5 000 American hospitals show that, currently, 40784 IT specialists are needed in order to get the complete EHR based on all registered electronic health data [9].

The survey conducted among the health information managers shows that, approximately 53% of them were clinic or office doctors mainly employed in the inpatient and outpatient hospitals earlier, and about 19% of them were the employees of consulting firms [21].

At present, the challenges related to the human resources in these countries are associated with the following problems [4]:

- certification of the specialists in health information management (Canada and the US have already started this process);
- certification of the specialists with necessary e-Health skills or regulating the licenses and providing legal base;
- training and search of people with appropriate skills to become a part of necessary workforce in e-Health;
- coordination of the strategy of e-Health staffing with the public health (healthcare) model.

9.3. E-medicine professionals and their competencies

[22] defines e-medicine as follows: "e-Medicine is a field developing at the intersection of health informatics, healthcare and business based on the transfer of health and information services over the Internet and related technologies. In wider sense, the term characterizes not only the technical development, but also the level of cognition and thinking manner to improve the healthcare in the regions and all over the world through ICT. Thus, e-medicine means computer applications, methods, tools applied in health system and the people performing all of these (suppliers, administrators, patients, families). For example, the studies and implementations conducted in the field of computer science are introduced to e-Health jointly by health information managers, researchers, technical experts and other field specialists [9, 11]. The professionals working in this field are called "e-Health experts".

E-medicine specialists are using the concepts of computer science, methods and tools by bringing them together to support healthcare processes. e-health professionals are referred to the health informaticians, health information managers, technical professionals and the specialists from various professions, who are capable to apply the concepts, methods and tools of computer science in e-halth to improve the effectiveness of healthcare system.

Health informaticians – specialists with the competencies of medical informatics in e-medicine. Health informatics is a discipline which studies the research, development, design, implementation and evaluation of the data related to the concepts, methods and tools supporting the healthcare procedure and medical administration. [13, 14] define the term "health informatics", and interpret the habits, skills and knowledge of these qualification owners. They are regarded as the e-medicine professionals, and called "the owners of knowledge and skills providing collection, processing and access to the health data, which supports the provision of health services." This definition also determines the future distribution of health informaticians.

They are ICT experts (creators, rulers and supporters of ICT infrastructure - currently approximately 37%), EHR-creators, developers, and executors (data organizers, who match and choose the information about the patient - currently approximately 26%).

[23] classifies the health informaticians as follows:

- applied health informaticians are the professionals, who are deeply aware of the fundamental concepts of health. They apply the methods (including planning, management, analytics, procedures, etc.) to support the health processes and carry out the installation of tools (e.g., information and communication systems). Their competencies are explained in [15] in details. One can master this profession with the Bachelor's degree or certification in the field of medical informatics.
- researcher-medical informaticians design, develop and evaluate the concepts, methods and tools of medical Informatics. The competence of these experts are provided in the section "exploration and development of medical informatics" in the works [5, 6, 13]. The researcher-health informaticians should have the bachelor's or scientific degree in the field of health information science. Those working at the educational institutions in the field of computer science usually tend to have scientific degree of PhD.

The professionals of both fields of computer science can be clinical informaticians, and those who deal with telemedicine, health policy, health informatics visualization, and so on.

Along with these two professionals, clinicians and administrators are also referred to health informaticians. Mastering advanced health informatics enough, they grow as professionals with clinical and administrative skills.

Health information managers (HIM) – the specialist managing the health information of e-health team. The Canadian Association for Health Information directs the scope of the health information managers to the health data. The experts managing the health information operate both at micro and macro levels of clinical information management. At micro level (or personal health record level), health information managers are in charge of collection, use, accessibility, promotion, maintenance, support and destruction of health records regardless of their format. Health information managers perform high quality analysis of EHR documentation and are responsible for the safety of EHR use. Ensuring the security and confidentiality of health information, the managers should be interested in protecting human rights. At macro level (or aggregated data level), the managers realize the statistical analysis of the information contained in the health records. They perform integrated management of information systems by taking into account the interests of the state and individual parties for the improvement of the population's health.

American association for health information management evaluates the health data management as owning the knowledge and practice which provides access to the HER to support decisions in real-time and critical situations. The managers can be presented as a clinical data specialist, the patient information coordinator, a manager of quality data organization, information security manager, information resource administrator, and a decision support expert.

Technical experts – e-health team members with one or more technical qualifications. The systems they mastered may include operating systems, databases, programming languages, software, applied software (production facilities, administrative information systems, office systems, etc.), different equipment, communication and networking tools, biomedical engineering facilities, security, risk management methods, procedures, and so on.

Other experts in health information technologies – refer to the professionals in ICT and business systems, human resource management and industrial engineering.

9.4. E-medicine specialist training

Training programs of e-medical specialists, in the best case, are aimed at achieving the intended (projected) number of graduates that are needed to solve the demand problem in the field of e-health. Each year, these programs develop 100 specialists on health informatics and 200 specialists on health information manager in

Canada. However, these short-term programs do not provide the demand for human resources in e-health. The short-term strategies also provide the training of the specialists and practitioners in the field of health information management and technical services.

Health informatics school in Canada was formed in 1981. The University of Victoria supports the program at undergraduate and graduate levels. During the previous years, the bachelor's program in health informatics was supported at the University of Dalhousie and Conestoga College, a master's program in health informatics was supported at the University of Dalhousie and the University of Toronto, and e-health is taught at the University of Mcmaster. Health information manager program is taught at the undergraduate level at the University of Ontario.

The available programs offer the opportunity to expand the profile of the profession of health informatics specialists and to get the professional certificate; they also offer marketing, search for the jobs for specialists in e-health, computer science and computer technique [19]. Long-term strategy for human resources is intended to coordinate the training in the field of e-health at all levels (undergraduate and graduate). These programs are accredited by the Canadian Association for Health Information Management, are meant for long-term training of the specialists in health informatics and e-health.

[8] states that 118 million USD was allocated for the training of specialists in e-health within the framework of *HITECH* program, which is shared among the following areas:

1) vcational training program in health informatics (70 million USD) - short-term certificate programs to train 10 000 experts in the colleges;
2) development centers program (10 million USD) – preparation of educational materials in local colleges and national educational institutions and their distribution through the center;
3) examination program on competences (6 million USD) - testing the local college graduates on their competences;
4) university preparation assistance program (32 million

USD) – developing the grants for the training of both undergraduate and graduate-level university students as the workforce with accordance to the certification programs.

Canada and several other countries are going to make changes to the national occupational standards for the development of national health services. [24] provides more attention to this problem and emphasizes the development of professional standards for the qualifications in health informatics as an important issue and justifies the development of the unified code in health information technologies.

The maintenance of health informaticians becomes challenging in national healthcare system. In general, there are some problems with satisfying the demand for health informaticians, EHR security, data protection and ICT staff on data development based. [14, 15] state that 43% of employees shifted to the similar positions in the private sector and 29% in the national health authorities. The reasons for this are low wages in the national sector, high demand, and difficult working conditions. However, mid-level health informaticians often have less problems. However, they also start to look for a better job as their knowledge and skills increase. Senior health informaticians are paid less than in the special sectors by 30–50%. Health informaticians often leave the workplace due to: 1) the lack of qualification and promotion; 2) the difficult working conditions (i.e., stress, unbalanced work regime, etc.); 3) and low wages.

The formation of human resources ensuring successful e-health the following offers are made in [15]:

- to be provided with a workforce in health informatics;
- to develop the effective strategies for the recruitment to fulfill the functions of the position required by the employer;
- to provide the information which depicts professional portrait of the health informatician and defines his/her future career growth (EHR, information management, information services etc.);

- to attract foreign workforce by providing incentive career growth (to attract those from other local medical clinics or the immigrants with necessary skills);
- to open the vacancies on health informatics in the companies;
- to develop lifelong education strategy;
- to develop the skills appropriate to the stages of the career growth in order to attract a wide range of health informaticians;
- to develop training programs (by different levels) on health informatics to ensure the sustainable development of knowledge, skills and experience for career growth;
- to maintain (to motivate)the workforce on health informatics;
- to ensure decent working environment, including fair wage structure;
- to record and reward achievements;

Australian national action plan specifies the importance of cooperating with the experts from all fields of health care system in order to define the demand for workforce on health informaticians [4, 13]. According to the Australian experience, it is important to define: first, who needs to study and what should be specifically learnt; second, which skills are vital. The action plan includes the following factors as the reasons for the lack of qualified specialists:

- lack of appropriate educational programs;
- lack of education funding;
- difficulty of attracting the students due to the unclear results of a health informaticians and health information managers, as they are new careers;
- low wages;
- lack of specialty status;
- new skills required for health informaticians and health information managers which are still not provided.
- lack of coordination and management;

- lack of a single program in the field of health informaticians and health information managers.

Canada and the United States created the positions of the national coordinator and social service on the problems of healthcare information technologies in the healthcare structures of these states in order to develop and implement a plan to improve the quality and efficiency of healthcare infrastructure with the use of information technology in 2008–2012 [24]. This plan promised to increase enrollments in health informatics in 2012 by 40%, and by more than 50% in 2014. American Health Information Association administration estimates 4000 unoccupied position of health information manager due to the lack of enough workforce in the United States. It declares the shortage in this profession and stresses that the national health infrastructure will fail without the workforce capable to use and perform advanced technologies [25]. It also states that the increase in the quality and quantity of the workforce in health informatics is a critical component of the transformation of American health care system and ICT. In [9], it is mentioned that in 2014, for the realization of the desired model of the national health infrastructure and general HER system, at least, additional 41 000 experts in health information management are required.

In advanced countries with forming E-health system, the national coordination centers and associations support the development of this field not only in their own countries, but also on undeveloped countries. American Association for Health Informatics received a grant of 1.2 million USD from Bill Gates and Melinda Foundation in December 2008 the development of workforce health informatics in the Latin America, Africa, the Middle East, Southeast Asia and the Pacific region countries [26]. The aim was to overcome the personnel shortage in health informatics in these countries, and to solve the problems of biomedicine and health informatics in education and training.

9.5. Big Data analytics personnel problems of e-medicine

Since 1980, stored digital information doubles every 40 months. Moreover, in recent years, it has been exponentially increasing. The generation of 2.5 Exabyte information a day (2.5 $x10^{60}$ bytes) since 2012, has led to the formation of fast, large-scale and complex data massive at all levels of society, which proves the beginning of the "scary big data" age [27, 28]. Big Data (BD) is a set of data, which is beyond the capabilities of the traditional database processing, collection, storage, management and analysis tools. In this sense, huge data processing by means of conventional systems is hard. That is why they are analyzed and processed in order to obtain important information by establishing the correlation between these data. This also requires the training of the specialties with knowledge and skills on BD. Table 9.1 describes the skills of this personnel by their categories [29]. The US base *SAS* analytical company forecasts that the need for BD specialists will increase by 160% in 2013-2020, as a result, the number of jobs in BD will be increased by 346 000 units reaching 1 million.

According to the recent studies, medicine is a field of science, in which extremely large amounts of data are accumulated, and 30% of collected and stored data throughout the world is health data [30]. Taking this into account, nearly 300 000 BD experts must be trained in medicine. Thus, the availability of the group of leaders and the personnel capable to how, when, where, and better way use the medical data is the demand of the day. In [29], it is stated that this staff earned £ 55,000 per year which is more than the salaries of IT professionals by 2%.

Table 9.1

Required staff qualifications on BD and their skills

	Qualifications	Required Skills
1.	BD creator	NoSQL, Java, JavaScript, MySQL and Linux together with TDD, CSS and Agile development knowledge
2.	BD projectors	Oracle, Java, SQL, Hadoop, and SQL Server and Data Modelling, ETL, Enterprise Architecture, Open Source and Analytics
3.	BD analysts	Oracle, SQL and Java together with Data Modelling, ETL, Analytics and Data Analysis
4.	BD administrator	Linux, MySQL, Puppet, Hadoop and Oracle along with Configuration Management, Disaster recovery, Clustering and ETL
5.	BD project manager	Oracle, Netezza, Business Objects and Hyperion together with ETL, and Agile Software Development – PRINCE2
6.	BD designer	Oracle, SQL, Netezza, SQL Server, Informatica, MySQL and Unix plus ETL, Data Modelling, Analytics, CSS, Unit Testing, Data Integration and Data Mining
7.	BD scientist	Hadoop, Java, NoSQL and C++ along with Artificial Intelligence, Data Mining and Analytics

9.6. Training of personnel in e-medicine specialties in Russia

Russia pays special attention to the personnel training for the formation of e-health. At many higher education institutions, the student enrollment in “medical cybernetics”, who will realize the transformation of medicine and ICT, is increasing each year. Medical Cybernetics – is a field of science dealing with the use of

Cybernetics, ideas, methods and technical tools in medicine and health care. The training of the professionals in “Medical cybernetics” is carried out at the following educational institutions of the Russian Federation:

- the Russian National Research Medical University after Piragov N.I. The training of this specialty started here for the first time in the department of medical biology;
- Siberian State Medical University (Tomsk);
- Penza State University;
- North-eastern Federal University (Arkhangelsk);
- Kazan (Privolzhsk) Federal University;
- Pskov State University;
- Krosnoyarsk State University after Prof. Voyno-Yasenetsk V.F.;
- South-Western State University (Kursk);
- Far Eastern Federal University (Vladivastok).

At present, “medical cybernetics” is a complete medical and its owner is a physician-cybernetics scientist. Physician-cybernetics scientist can not work as a surgeon, therapist and other senior medical specialist (doctor-clinician) or enter residency. The graduates can work at clinical laboratory, functional diagnostics, radiology, and in the field of medical physics.

Health Cybernetics can be presented in two groups:

1. *Mathematical diagnosis of diseases* – is associated with the use of computer techniques in the data processing incoming from a biological object. In this case, the graduates of “health cybernetics” can work as the following physicians [31]:

- Clinical laboratory diagnostics physician;
- Physician-bacteriologist;
- Physician-virologist;
- Physician-geneticist;
- Physician-mycologist;
- Physician-radiologist;
- Ultrasound diagnosis doctor;

- Functional diagnostics doctor.

The graduates of this specialty can work for the informatization of healthcare at medical institutions, health information-analytical centers, healthcare management centers, health insurance companies, including the companies developing and operating health information systems. They can also deal with the maintenance of medical diagnostic equipment.

2. *Automated control systems and their capabilities in healthcare.* The graduates of the specialty are able to achieve the knowledge in the following areas [32]:
   - Development, application and use of automated health information systems;
   - The use of computer techniques in the health data processing;
   - Using modern clinical laboratory, bio-physiological and bio-chemical devices at the laboratories and departments of the medical and scientific organizations;
   - Verification of electronic-medical apparatus and basic troubleshooting;
   - Receiving therapeutic, surgical and neurological patients, defining their main symptoms and syndromes to set the preliminary diagnosis;
   - Drawing up a plan of laboratory and instrumental analysis;
   - Conducting the researches in clinical laboratory, biochemistry, bio-physics, immunology and medical genetics;
   - Appointing the diagnosis based on the results of the clinical, laboratory and instrumental studies, and selection of treatment tactics;
   - Organization and planning of the medical staff;
   - Organization of a variety of events related to the population's health, healthy lifestyles, environmental health effects, and the prevention of diseases;

- Providing emergency medical aid;
- Delivering the laboratory and practical lessons in natural sciences, biomedical and clinical subjects at higher education institutions and colleges;
- Developing scientific and methodological materials on the professional activity.

The professionals in this specialty should be ready for the solution of the following issues [33]:

- development of public health planning and forecasting models with the use of mathematical methods and computational techniques;
- use of mathematical methods and computational techniques for the solution of the statistical data processing;
- development of the information support of the automated health care control system;
- development of the functional system model of an organism - the physiological system of the separate human organs, and their use for the diagnosis of the patient's condition, automated control and forecasting with the use of information technology;
- use of applied software packages for the solution of computing diagnosis and the detection of informative indicators out of the clinical data massive;
- use of technology for the development of medical expert systems;
- diagnosing the diseases by mastering the instrumental and laboratory research methods;
- providing diagnosis and first aid in the emergency situations;
- providing the medical aid to the population in the emergency situations as the epidemic spread, mass lesion and so on.

The subjects taught in this specialty are:

- computer science [34];

- information technologies in social sphere [35];
- computer science in psychology [36];
- health information systems;
- clinical cybernetics;
- clinical laboratory diagnostics;
- medical biophysics;
- medical electronics;
- general and medical radiobiology;
- system analysis and healthcare organization;
- theoretical basis of cybernetics;
- physiological cybernetics;
- functional diagnostics.

9.7. E-medicine staff training in Azerbaijan

"Medical physics and informatics" department is operating (formerly called "Medical and Biological Physics" (adjunct to the course of computer science and computer engineering) at the Azerbaijan Medical University.

The subjects "Medical and Biological Physics", "Higher Mathematics" and "Computer science" are taught at this department. "Computer science" is taught at the 1st course of the bachelor degree and the courses on the office programs are taught one term at the master degree [1, 2].

Azerbaijan State University of Oil and Industry is training the staff on "Biomedical technology engineering". The Students, majoring in biomedical technology engineering, are taking the subjects, as biology, computer science, biophysics, medical methods of diagnosing, computer technologies, physics, computer and engineering graphics, information technology, biomaterials and so on. These students are taught how to practice new biomedical devices, to introduce new developments in the production, to set up and operate biomedical equipment, to develop new biomedical devices and tools (computer tomography, blood pressure measuring devices, etc.), and to realize the certification and attestation of new biomedical technology.

The graduates of “Biomedical Technology Engineering” can work as an engineer, laboratory engineer, medical equipment engineer, and environmental protection engineer at treatment and diagnostic centers, medical-biological centers, clinics and other relevant institutions.

Drawing upon the experience of developed countries, below recommendations need to be considered for the preparation of respective workforce and human resources, which is the principal guarantee of the formation of e-health in Azerbaijan:

- demand for the personnel with the specialties appropriate to the e-health formation should be determined;
- short and long term strategies and programs, which provide the training of required qualifications, should be adopted;
- courses should be organized for the medical staff at different levels to develop their ICT knowledge and skills;
- parties interested in the identification of the skills and competencies necessary for the e-health workers: government, educational institutions, medical and IT experts, educators should be involved in this work;
- new educational programs and professional standards in the field of health informatics should be developed;
- qualifications should be recognized for the workforce recruitment, employee retention (motivation), and the stages of career growth shall be designed;
- relevant associations and centers should be established for the coordination of experts.

The realization of all above-mentioned items can be a successful step towards the integration of Azerbaijan into the international e-health environment.

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CHAPTER 10. MODELLING OF THE INTERACTION BETWEEN SUPPLY AND DEMAND FOR MEDICAL STAFF

The results of health system activity and quality of medical service rendered to the population completely depend on quality and quantity of MS. Therefore, the improvement of medical staff stock and raise of health specialists professional level are important challenges the special attention of each country and generally of WHO is given to [1–3]. Currently great significance is attached to highly qualified staff training, additional training for perfection of professional qualities, knowledge and skills of health specialists, staffing and improvement of health quality indicators.

10.1. Staffing in medicine

Despite of all abovementioned, the tendency of staff shortage, personnel decrease is now observed [4–7]. It is announced that number of staff shortage in USA for 2020 is prognosticated to be 85000 people, and for 2025 the demand and supply will gain the upper hand from 46000 to 90000 [7]. The number of doctors per 10000 people for 2011–2014 has decreased in Ukraine from 49 to 48, in Belorussia – from 54 to 39 [8]. In Turkey the number of people per a doctor is 595, whereas this indicator equals 262 in Germany, 203 in Ukraine.

The number of doctors per 100000 people was 501 in 2009, whereas in 2011, this figure decreased to 418. In 2012, the number of doctors decreased by 7261, resulting in the demand for 150 000 doctors [6–10]. It is reported that the number of doctors per 10000 people in Russia in 2013 and 2014 was 49 [8].

Under the total number of doctors it is provided to take into account all highly-educated doctors who work in treatment, sanitary, social security institutions, scientific and research institutes, postgraduate education training and other health bodies [8].

MS also include nursing staff (paramedic, obstetrician, nurse). Most of the world countries claim the shortage of nursing staff. Despite the doctor/nurse ratio number in Finland equals 1:4,3, in Norway –1:4,7, and in Denmark –1:5,6, these countries still announce the fact of nursing staff shortage [5-6], as in Britain nurse shortage number was presented up to 35000, and in Finland up to 100000. One of the factors generating this problem is application of information and communication technologies, as well as modern innovative medical technologies in medical sphere, formation of e-health, and it reasons the partial decrease of demand for doctors and increase of demand for nursing staff [11–13].

Thus, present picture in the sphere of doctor and nursing staff displays the excess of demand over the supply in health specialist labor market, and it makes the issues of regulation and management of demand and supply for health specialists essential at governmental and WHO level [1–4].

Successful solution of this problem requires complex approach to the problem, and development of comprehensive strategy encompassing staff compensation, working conditions, their recruitment and retention issues. Still, there is not any standard model in this direction as well as any country to borrow its "best practice" in order to find appropriate problem solution to the stated issue [3].

According to the results, abovementioned issues in health specialist policy have been partially embraced in such countries leading in the medical sphere as England, Belgium, Germany, Ireland, Spain, Lithuania, Slovenia, Finland, Australia and Canada. In these countries, necessary source for monitoring of health specialist labor market is the availability of database maintaining reliable, precise and new data.

In order to find the answers to all abovementioned questions and in the development of correct staffing policy, the priority is given to sociological survey method, initiated by WHO from 1990. Topicality of this approach reasoned by the lack of scientific methodology in this field, and shortage of scientific works devoted to this issue [3].

The study proposes a scientific and methodological approach to the management of supply and demand in the market of medical staff, and develops a model based on fuzzy situations analysis and fuzzy images recognition for the management of supply and demand [14–17].

10.2. The state of supply and demand for MS in Azerbaijan

The personnel in the medical sphere in Azerbaijan is tending to decline. The State Statistics Committee reports that this fact is represented in the decline in the total number of doctors and the number of doctors per 10,000 people in recent years (figure 10.1, figure 10.2) [18].

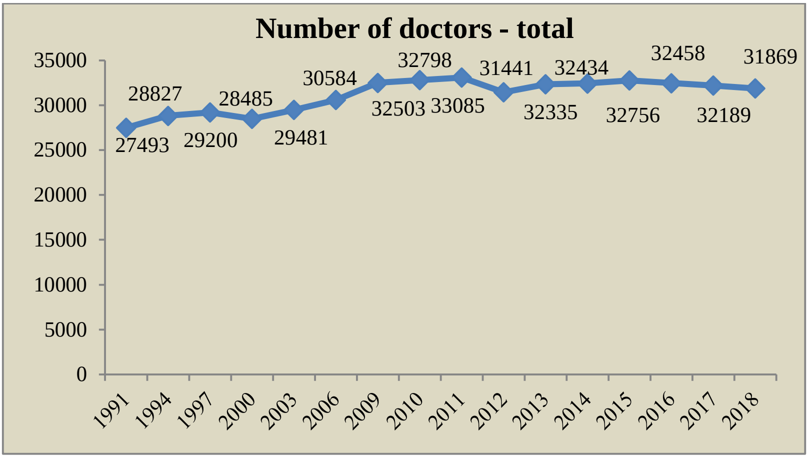

Figure 10.1. Total number of doctors in Azerbaijan [19]

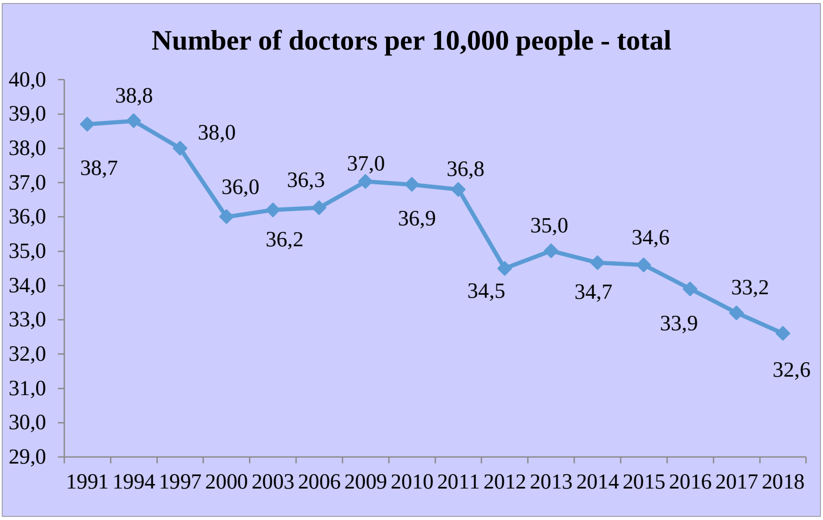

Figure 10.2. The number of doctors per 10000 people in Azerbaijan

Regarding the structure of employment of doctors in Azerbaijan, the situation is the same as in Western countries, thus, the more the number of doctors increases, the more the number of doctors per 10000 people is decreasing.

For example, although the number of therapists increased from 7841 to 8,129 since 1991, their number per 10,000 people decreased from 11.1 to 8.3; the number of surgeons increased from 2661 to 3358, while their number decreased from 3.8 to 3.4 per 10,000 people; the number of gynecologists increased from 1428 to 1762, while their number decreased from 4.0 to 3.6 per 10,000 people. The number of pediatricians increased from 4271 to 3585 since 1991, whereas their number decreased from 15.4 to 13.7 per 100,000 people.

Figure 9.3 represents the dynamics of the number of nursing staff for years 1991-2018, and their number decreased from 6,8037 to 52,807 over these years.

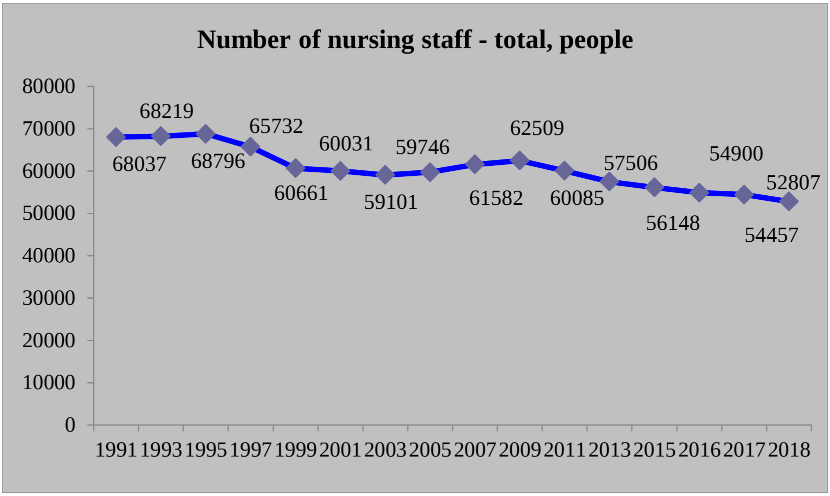

Figure 10.3. The number of nursing staff in Azerbaijan [19]

As a result, the number of nursing staff per 10,000 people accounted for 54,0 in 2018 (figure 10.4).

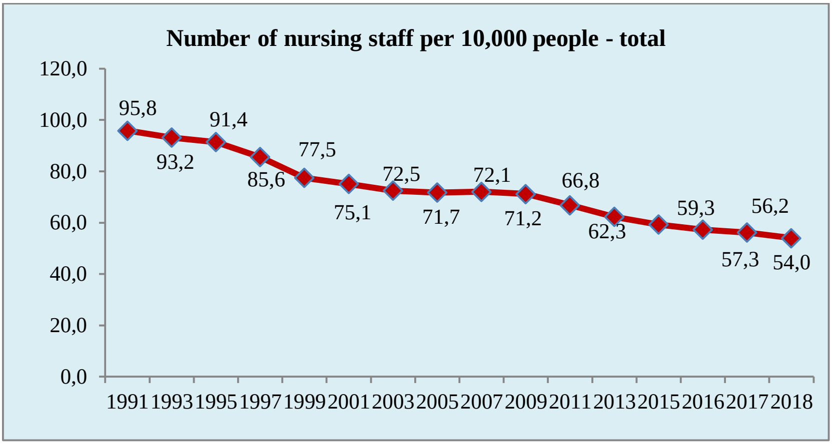

Figure 10.4. The number of nursing staff per 10,000 people in Azerbaijan

The dynamics of the number of specialists trained by higher education institutions and secondary education institutions in recent years also represents the decline (figure

10.5, figure 10.6). Thus, the number of specialists trained by higher education institutions in Azerbaijan accounted for 1332 in 2000, 1168 in 2010, and 1363 in 2017.

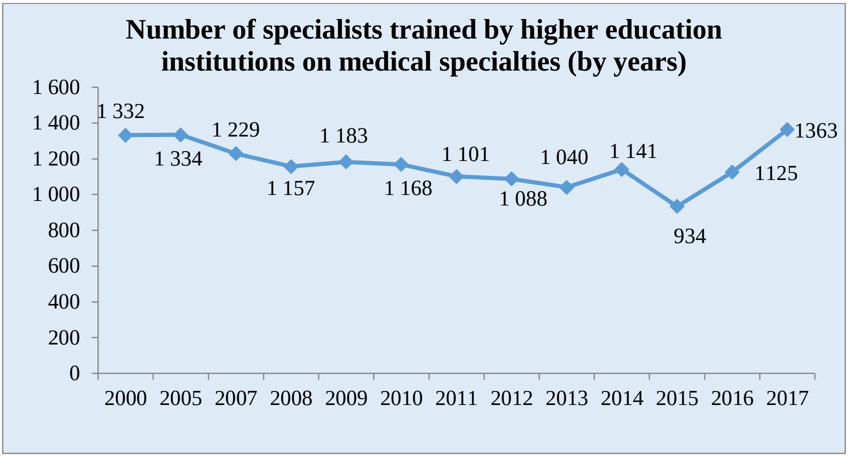

Figure 10.5. The dynamics of the number of specialists trained by higher education institutions

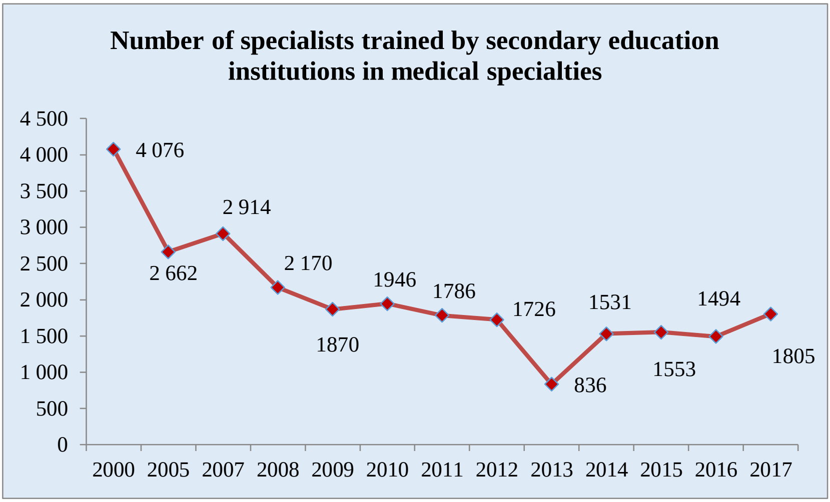

Figure10.6. Dynamics of the number of specialists trained by secondary education institutions in medical specialties

The number of specialists trained by the state secondary education institutions in medicine in Azerbaijan was 4076 in 2000 and 1805 in 2017.

The proportion of doctors/nursing staff in Azerbaijan was 1: 2,7 (27493: 68037) in 1991, 1: 2,1 (28485: 60565) in 2000, 1: 1.9 (32798: 62899) in 2010, and 1: 1.7 (52807: 31869) in 2018. The dynamics of the number of doctors/nursing staff in Azerbaijan is given in the following graph (figure 10.7).

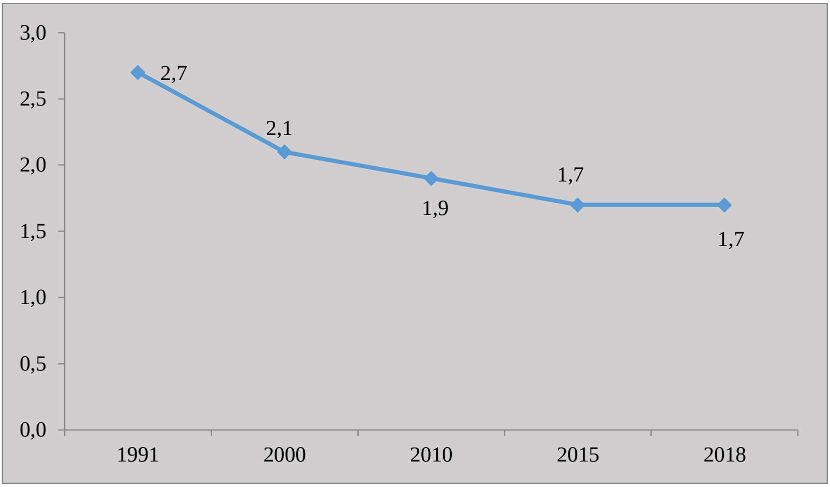

Figure 10.7. Dynamics of the proportions of doctors/nursing staff in Azerbaijan

One of the indicators representing the decline in the number of nursing staff is defined by the number of nurses per hospital bed. In Azerbaijan, this indicator was 0.45 (31604:69900) in 2001, 0.88 (37941:43200) in 2013 and 0.85 in the 2018 (37322:44100). The dynamics of the number of nurses per hospital bed in Azerbaijan is given in figure 10.8.

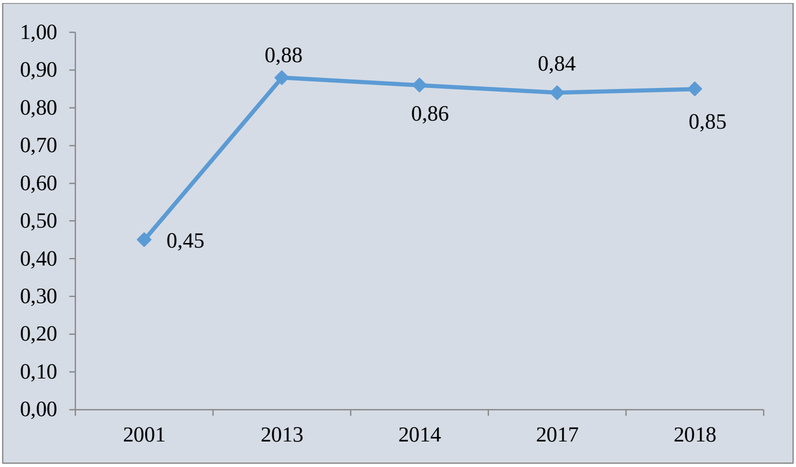

Figure 10.8. Dynamics of the number of nurses per hospital bed in Azerbaijan

10.3. The impact of the development of information technologies on medical professionals

Formation of information technology and e-medicine will ensure better healthcare and reduce the demand for doctors [11]. One of the studies in this field is conducted by the US Dr. Jonathan Weiner. This approach is based on the tendency of the introduction of IT into healthcare and the formation of e-medicine. J.Weiner is Dr., Professor, Health Policy & Management and Health Informatics; Director, Center for Population Health Information Technology, Johns Hopkins Bloomberg School of Public Health.

Once HIS is fully established and its relationship is fully provided, doctors will be able to easily share the service delivered to the patient with the nurses and medical assistants. This approach provides access to a broad profile physician-specialists who will reduce the demand for doctors and increase the demand for practical nurses.

[12] provides the results of the surveys carried out to show how HIS, which is used 1) by 30%;

2) 70% of doctors-practitioners affects the demand for physicians.

The study reveals that the implementation of the first version is expected to result in a decrease in the number of physicians by 4-9%, while the realization of the second version is predicted to decrease the number of physicians by 8–19%, and to increase the number of nurses by 10–20% and the number of medical assistants by 5–15%.

Thus, the informatization of medicine and the formation of e-medicine affect the demand for medical workers, and at the same time, revolutionize traditional medicine. This, unquestionably, is determined in relation to the medical staff with the skills in informatics to the number of general medical personnel or the total number of population. This figure was first calculated in the UK with the population of 50 million and a total of 1,3 million people employed in the *National Health Service* and accounted for 25,000 employees, i.e. a medical employee with the skills in informatics per 52 workers [20].

In Australia, where the total population is 21 million, the number of medical employees with the skills in informatics working in healthcare is 12,000, the ratio of the number of healthcare professionals with the skills in informatics to the total number of employees is determined as 1:50 [21].

In the US, the surveys in this field has been conducted on specific occupations, service areas, hospitals, or integrated units. Gartnet Research reports that this figure for 40 distributed systems is 1:48, however, in another study, this ratio accounts for 1:60,7 [22, 23].

[24] emphasizes that in the five-year training program, it is estimated that 7600 full-time employees with the skills in informatics have to be trained to provide HIS access for 400,000 physician-practitioners, 28,600 employees – for joining 4,000 hospitals to this system, and 420 employees for the implementation of the network infrastructure. The national

coordinator on HIT (Health IT) reports that 5,000 new human resources are required for the implementation of the EMC system specified in *Health Information Technology for Economic and Clinical Health* [25].

10.4. Specific features of the MS labor market

According to WHO's initiative, the medical staff has to be assessed by their competency and position every 5, 10, 15 years in each country [3]. This is chiefly demanded by the following 4 arguments:

1) the demand for health care services varies depending on the changes of the demographic, epidemiological, cultural and social characteristics of the population;

2) the users' expectations change, migration occurs, technical innovations (diagnostic and treatment equipment and methods; telemedicine) develop and organizational changes aimed at improving the quality of health of the system (the first medical and sanitary aid, working on brigade method, services integration, new contract terms and working conditions) arise;

3) feminization of some professions (e.g. dentistry) takes place, and opinions of the current workers towards the quality of life differ from the previous generation of workers and these changes affect the activity of the labor market and labor productivity;

4) changes taken place within the period of time between the decision making and its implementation in accordance with these changes should be taken into account.

The training of new personnel requires opening of new educational institutions, while attracting additional human resources with new quality requires the analysis of existing curriculum and development of new ones. All this takes years.

At present, as an important part of the assessment of the demand for medical personnel, the followings shall be applied:

- identification of the demand for personnel in regions;
- estimated number of population;
- technological and social changes;

- vocational qualification structure;
- quality of professional performance on individual-level;
- healthcare policy [3, 4].

Thus, here are the following challenges to define demand and supply for medical specialists:

- What will be future short-, medium- and long-term perspectives for demographic, epidemiological, social and cultural characteristic features of the population?
- Increase of which chronic illnesses, psychological states is prognosticated, and emerging probability of new future diseases in the result of migration flow and climate changes?
- What are the requirements for appropriate future medical service?
- What will citizens' and users' requirements be, who will be financing appropriate medical services?
- How will the technological and organizational change affect the demand?
- What kind of specialists and their amount (general practitioner, specialist physicians, paramedics, nurses and others) will be required?
- What responsibilities and education of the MS together with their compensation rates will be in demand?

In terms of coverage of medical services rendered to the population, to ensure the adequacy of assessment the demand for the medical staff with the reality, the demand for the personnel depends on the expectations from the "adequate human resources" in terms of final outcome quality (figure 10.9).

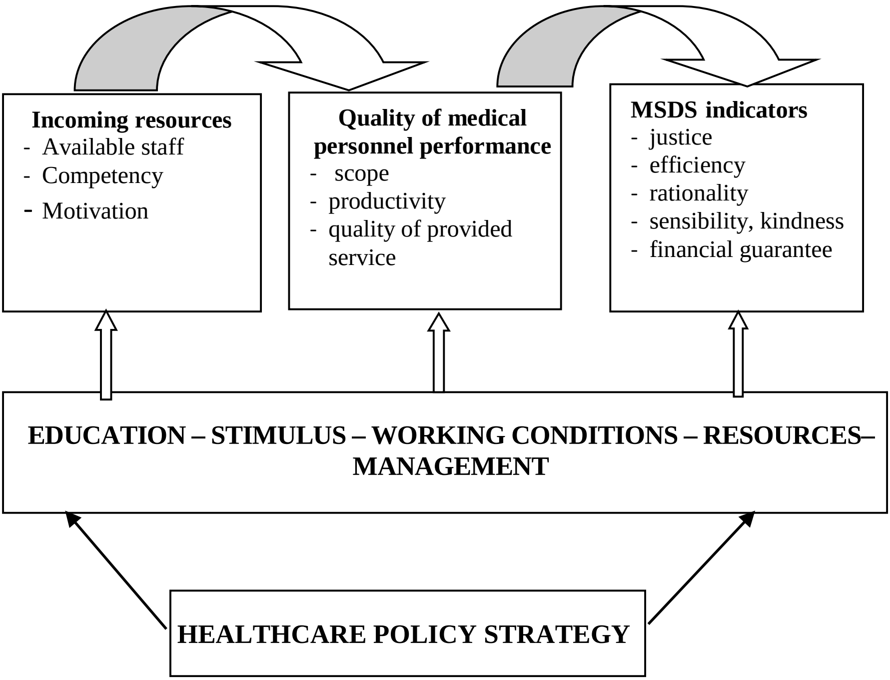

Figure 10.9. The quality of medical personnel and medical service delivery system (MSDS) performance [3]

Thus, the correct prediction of demand requires a proper evaluation of the current situation of the medical staff and the future stuffs incoming and outgoing from this market (figure 10.10).

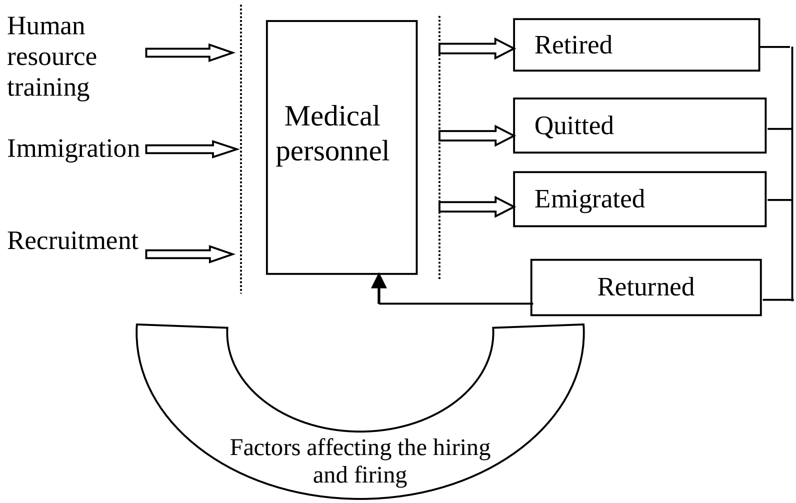

Figure 10.10. Model of the existing human resources’ dynamics in healthcare [3]

The following approaches and methods are used for the assessment of demand for medical personnel:

- assessment based on the ratio of the total population to the number of medical staff;
- assessment based on the medical service indicators and the demand for these services;
- assessment based on the aimed service indicators;
- assessment based on needed medical services.

These approaches, according to the WHO’s initiative, are referred to the survey methods and allow quantitative assessment of supply and demand of the medical staff.

Above-mentioned factors of supply and demand in the market of medical personnel characterize it as a socio-economic (“soft”) system, because the main resource of the labor market is a human, his intellectual capacity, personal and psychological qualities, his value, without which the management of the social system will not be effective.

The specific features of the MS labor market, the uncertainty of information flows about its state, the much-varied profile of data on MS and the difficulties of measuring it, and the ambiguity of indicators characterizing it predetermine the variety of possible fuzzy states of supply and demand for MS and the multi-option pattern of reconciling them. Comparisons and evaluations of these conditions and the choice of the reconciliation policy can be efficiently accomplished with the use of intellectual methods and technologies. The latter help to integrate the versatile information on the supply and demand conditions and facilitate the development of a set of alternatives for managerial decisions and the selection of the most efficient one among them. Management in such systems is considered as a process of identification of the demand and supply condition at a given point in time and decision making suitable in the current situation.

10.5. Modeling the interaction between supply and demand in the MS labor market

The rise of an information economy emphasizing knowledge as its major value produces a significant influence on labor market deformations. The emphasis shifts toward human resources and the creative aspect of activities which modifies the basic foundations of a "transaction" in the supply and demand relationship [26, 27].

In medical sphere, these features are represented more clearly, so the subjects here must demonstrate that they are intellectual potential carriers with certain personal, cultural, behavioral quality, and that they ready to adequately apply their competencies in particular workplace.

Given the realities of the modern labor market, the employer understands that the employee is a key strategic resource of the organization and tries to find and introduce new innovative approaches to the personnel policy (recruitment, job retention and motivation of staff). Nowadays, it is impossible to gain the maximum results from an employee with minimal expenses on his/her development. No expectation is warranted of a creative approach to job tasks or quality level of performance without considerations for the MS preferences (aspirations, interests, and motivations) facilitating his or her professional and often personal development [28].

The task of modeling and managing the interaction between demand and supply in the market for MS can be considered at micro and macro levels [29]. The micro level identification of the supply and demand conditions is viewed from the point of individual subjects in the MS labor market and their behaviors and strategies. At the macro demand level, the basic unit is an enterprise because, it is at the enterprise level that the demand for MS is shaped in terms of structure and volume, as well as requirements regarding professional and personal competencies. In this case, the task of defining the level of conformity between supply and demand consists of the development of efficient selection and recruitment of MS.

At the macro level, the task of modeling and managing the interaction between demand and supply in the MS labor market, depending on the objectives, comes to balancing the supply and demand for HS within different territorial and geographic areas (at the industrial, regional, and nationwide levels, etc.) (Features of diseases in the regions, which specialty of doctors is demanded, distribution of the doctors, training of qualified personnel, the situation in the related field of education, the need for reforms in education, etc.).

Success in performing job functions depends on the MS's intellectual potential, level of certain professional and personal competencies, willingness to properly employ them in the workplace, and desire and ability to expand and update professional knowledge and experience in line with functional requirements. Against this context, it seems worthwhile to address the labor market as an intellectual environment [30, 31] where the commodity is knowledge, abilities and skills.

By intellectual smart management of the MS labor market, the authors mean managerial decision making to bring down the imbalance between the demand for MS and their supply which comes to a choice between possible alternatives of the supply and demand reconciliation policy toward solutions that will satisfy as fully as possible the aims and conditions of the objectives set and the needs, preferences, interests, aspirations, and capabilities of the key market subjects, i.e., employers and MSs, while bringing down the gap between the demand and supply as much as possible.

10.6. Formulation of the problem

Suppose $M_V = \{V, K, G, Q, U^p\}$ sets the model of demand for MS defining the competence requirements for those applying to a particular position. It represents the system of employers' preferences for candidates to a particular position expressed as a set of sought competencies of the right candidate and shapes the reference search profile of MS. Here, V is the set of vacancies expressed by candidate requirements for MS positions by employers [14, 15];

$K = (L, C)$ is the set of basic competencies characterizing MS, comprising the set L of personal competencies required for working in MS and the set C of professional competencies representing the required functional abilities for filling a particular vacancy;

G is the system of the employer preferences with respect to levels of particular measures;

$Q : V \cdot K \cdot U^p \to G$ is the decision rule (evaluation model) for mapping of the set of preferences to the set of competencies;

U^p is the set of conditions offered to candidates applying for medical vacancies.

The supply model $M_S = \{S, K, W, Q^*, U^s\}$ reflects actual value of competencies and preferences of each individual MS, thus defining the search profile (professional profile) of MS. Here, S is the set of MS looking for work and aspiring to a particular position;

$K = (L, C)$ is the set of personal and professional competencies of an individual MS, a potential candidate to a particular vacancy;

W- is the set of preferences of MS;

$Q^* : S \cdot K \cdot U^s \to W$ is the mapping of the set of preferences of MS to the set of competencies;

U^s is the workplace requirements of MS.

The interaction between the set of reference demand conditions for MS and the set of actual conditions shaping their supply create the set of unique semi-structured (fuzzy) situations.

The purpose of managing supply and demand in the MS labor market is to identify (recognize) among the sets of actual search profiles of MS and reference search profiles the particular combination (pair) that shows the highest degree of agreement (convergence) of elements both from the point of preferences (reference requirements) of the employer and from the point of aspirations of the candidate.

With a mechanism available to evaluate supply and demand conditions and the degree of their conformity through the prism of the subjects' interest in the MS labor market, managerial decisions can be made as to the selection of the best candidate to a position (consequently, selection of the best job).

In formal terms, the problem of identification of supply and demand conditions can be defined by three components $D = < V, S, R >$, where:

V is the set of vacancies;

S is the set of MS;

R is the set of rules defining the relationship between the elements of sets *V* and *S*, i.e., rules helping to compare the descriptions of actual conditions of MS with all reference conditions of the demand side.

The recognition and evaluation of supply and demand conditions take the form of the mapping $F : D \to Z$, where Z is the solution of the problem D set with the intellectual system as a particular target condition meeting the purpose of recognition and evaluation in a particular situation [32, 33].

10.7. Possible scenarios of supply and demand in the MS labor market

After the identification of the most acceptable employer (decision maker) – MS “pair” is completed on the basis of the degree of convergence among the sets of actual and reference search profiles, several possible scenarios are possible:

Scenario 1. One vacancy (employer request) – one applicant (MS).

In this case, if the degree of fuzzy convergence between two situations (reference search profile and candidate’s search profile) is not lower than the employer’s set threshold, then the decision is made to hire.

Scenario 2. The employer’s preferences are met by several applicants (MS) at an acceptable degree of convergence of two fuzzy situations. They form a subset of fuzzy situations (alternatives), and the most suitable one should be selected.

In this case, the employer acting as an expert (decision maker) can be offered the following methods of decision making [34–38]:

(a) compare the degrees of convergence of reference and actual situations by the significance levels of the criteria characterizing the applicants to the vacancy and make a decision based on the convergence in the more significant criteria;
(b) expand the list of evaluation criteria, further define input situations, and repeat the procedure of recognition;
(c) reduce the problem to multi-criterion choice of the best solution (alternative) taking into account the relative significance of criteria characterizing MS.

Scenario 3. Several employers who are interested in hiring of one MS are identified. A reverse problem occurs in this case: a subset of fuzzy reference situations (alternatives) is given in the form of proposed vacancies of different employers with fitting conditions, from which the MS has to choose in accordance with his preferences. In this scenario, the decision maker's role lies with the MS who can:

(a) compare the degrees of convergence between his aspirations and the criteria defining hiring conditions and make a decision based on the convergence of the most significant criteria;
(b) expand the list of criteria for workplace evaluation, further define input situations, and repeat the recognition procedure;
(c) reduce the problem to a multi-criterion choice of the best solution (alternative) taking into account the relative significance of criteria characterizing workplaces.

The proposed method is one of the possible options to help employers make reasonable hiring decisions to fill vacancies. The need for such assistance is dictated by a number of factors including the dynamic patterns of the business environment, the narrowing life cycles of implementing new ideas and technologies, and the need for systematic implementation of innovations to maintain competitive strength of the organization. In such circumstances, modern employers must constantly adapt their solutions to constantly changing managerial situations. Moreover, nowadays, the share of decisions to be made in uncertain and unconventional situations is rising significantly at all levels of management. While human resources are the main factor of competitive strength for organizations, the issues of support of decision making in managing staff and its intellectual potential have gained strategic importance.

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CHAPTER 11. METHODS MANAGING FOR MATCHING SUPPLY AND DEMAND ON THE MEDICAL SPECIALISTS

Provision of human resources and the professional level of the medical employees are the most essential and vital factors directly affecting the quality of the medical services delivered to the population. Thus, improvement of the health workforce and developing the professional level of the medical employees are the priorities of each country and the WHO as a whole [1–3]. The program "Assessing future health workforce needs" adopted by WHO and European Observatory on Health Systems and Policies of the WHO defines the balancing supply and demand for the health workforce as a global problem [3]. The relevance of this problem is proven by the policy of the European Union and Green paper on the European workforce for health introduced in 2008 [4]. Successful resolution of the pending issue requires the development of a comprehensive strategy covering issues such as an ample approach to the problem, staff wages, working conditions, recruitment and motivation. However, a standard model in this area is not available yet, and there is no a country with the good practices which would be conducive to solving this issue. Nevertheless, at present, sufficient attention is not paid on the solution of the problem in the scientific literature [3].

This chapter proposes a methodological approach for the management of the demand and supply in the market of health workforce, and provides methods for the solution of intelligent management of the demand and supply in the medical institutions based on fuzzy situation analysis and similarity. Whilst mentioning the intelligent management of the health workforce market, the authors consider such management solutions selected among the possible alternative options of compliance policy of supply and demand in order to reduce the imbalance of between the supply and demand to the medical professionals [5–8]. This decision would fully comply with the aims and conditions of the problem, to the requirements, interests and terms of the main subjects of the labor market, which are employers and medical experts, at the possible extent, and would minimize the deviation between the supply and demand [9–12].

11.1. Compliance of demand and supply for MSs

People, their intellectual potential, personal and psychological qualities are the main resources of the health workforce market [5, 6]. The specificity of the health workforce market, the uncertainty of the data sets about its situation, the diverse nature of the data about the health workforce and in most cases, the impossibility of their measurement defines the diversity of fuzzy situations of supply and demand for medical specialists and the multi-variation of their possible balancing.

Making decisions on the solution of comparison and assessment issues of these situations and selection of their relevance policy may be effective through the use of intellectual methods and technology. These tools may form a set of alternative options of management decisions related to the supply and demand situations. In such systems, the management is considered as a process of identification of the situation of supply/demand at a certain moment and management decision-making adequate to the current situation.

Taking into account the fact that the structure and volume of the demand for MS, the requirements to their professional and personal competencies are established at health institutions, the study case reviews the compliance issue of demand and supply at the level of health institutions to adapt to the level of popular are considered in the article. In this regard, the solution of the issue of the compliance of supply and demand is reduced to the development of mechanisms for the selection and recruitment of health specialists. Successful implementation of the professional duties by the health workforce depends on their intellectual potential, a certain degree of mastering the professional and personal competencies, readiness to use them in particular workplace, and their desire and ability to regularly improve and update the knowledge and skills in the professional area.

In this context, the labor market should be considered as an intellectual environment which yields knowledge, skills and abilities [13, 14].

11.2. Fuzzy situation models of supply and demand for MS

Assume the demand for MS labor market is defined by the following sets [9–12]:

$V = \{V_1, V_2, ..., V_k\}$ or $V = \{V_i\}, i = \overline{1, k}$ expresses a set of vacancies;

$L = \{l_1, l_2, ..., l_n\}$ or $L = \{l_i\}, j = \overline{1, n}$ is a set of personal features (characteristics) required in a candidate to a particular position (position, workplace); $C = \{c_1, c_2, ..., c_m\}$ or $C = \{c_f\}, f = \overline{1, m}$ is an open set of competencies sought to fill the medical vacancy; $U = \{u_1, u_2, ..., u_p\}$ or $U = \{u_\gamma\}, \gamma = \overline{1, p}$ is a set of terms offered to the applicants to vacant medical jobs.

The demand model $V = (L, C, U)$ can be described by three matrices as $V_L = \|l_{ij}\|_{kn}$, $V_C = \|c_{if}\|_{km}$ and $V_U = \|u_{i\gamma}\|_{kp}$, where every $i = \overline{1, k}$ of the row V_i characterizes individual vacancies in the medical labor market; the columns (l_{kn}, c_{km}, u_{kp}) represent the constantly expanding base of personality features and competencies; the elements l_{kn}, c_{km} express the level of individual characteristics required to fill the vacancy, and u_{qp} are the values of measures characterizing the conditions proposed to applicants for a particular vacancy. The degree of conformity of the vacancy V_i ($i = \overline{1, k}$) by the indicators l_{ij}, c_{if} and u_{kp} is defined as fuzzy sets with membership functions

$$\mu_{l_{ij}}(V_i): V \times L \to [0,1],\ \ \mu_{c_{if}}(V_i): V \times C \to [0,1],$$
$$\mu_{u_{i\gamma}}(V_i): V \times U \to [0,1] \tag{11.1}$$

expressing the levels of membership required by the employment on separate indicators to fill the vacancy.

Assuming that the medical specialists seeking and applying for a vacancy in the labor market is given as a set $S = \{S_1, S_2, ..., S_q\}$ or $S = \{S_g\}$, $g = \overline{1,q}$. $L = \{l_i\}$, $j = \overline{1,n}$ is a set of actual competencies characterizing the health specialists, $C = \{c_f\}$, $f = \overline{1,m}$ is a set of actual competencies in each individual applicant to a vacancy, $U = \{u_\gamma\}$, $\gamma = \overline{1,p}$ is a set of preferences of the medical specialist expressed in the requirements of the medical expert for the medical vacancy.

The supply model $S = (L, C, U)$ is also given as three matrices $S_L = \|l_{gj}\|_{qn}$, $S_C = \|c_{gf}\|_{qm}$, and $S_U = \|u_{g\gamma}\|_{qp}$, in which each row of (S_g) ($g = \overline{1,q}$) characterizes individual candidates to proposed vacancies in the medical job market; the columns (l_n, c_m, u_p) reflect the constantly expanding base of personal features and competencies; the elements l_{qn}, c_{qm} are the levels of individual attributes required to fill the vacancy; and u_{qp} is a set of the indicators describing the requirements of the medical specialist for the vacancy. The degree of a competency of a certain medical specialist S_g with the individual features $g = \overline{1,q}$ *L*, competency *C*, and the vacancy requirements *U* is defined by the following membership function:

$$\mu_{l_{gj}}(S_g): S \times L \to [0,1],\ \ \mu_{c_{gf}}(S_g): S \times C \to [0,1],$$
$$\mu_{u_{g\gamma}}(S_g): S \times U \to [0,1]. \tag{11.2}$$

In fact, there are two sets of fuzzy situations describing the conditions of demand $\tilde{V}_i$ and supply $\tilde{S}_g$ in the medical specialist labor market:

$$\tilde{V}_i = \{< \mu_{l_{ij}}(V_i) >, < \mu_{c_{if}}(V_i) >, < \mu_{u_{i\gamma}}(V_i) >\} = \{\mu_{V_i}(y)/y\} \quad (11.3)$$

$$\tilde{S}_g = \{< \mu_{l_{gj}}(S_g) >, < \mu_{c_{gf}}(S_g) >, < \mu_{u_{g\gamma}}(S_g) >\} = \{\mu_{S_g}(y)/y\}. \quad (11.4)$$

Here, the set $\tilde{V}_i = \{\mu_{V_i}(y)/y\}, i = \overline{1,k}$ accounts for fuzzy referencesituations, i.e., sought fuzzy images of demand. Moreover, the set $\tilde{S}_g = \{\mu_{S_g}(y)/y\}\ g = \overline{1,q}$ accounts for fuzzy real situations, i.e. sought fuzzy images of supply. Thus, the purpose of the task is to identify the similarity of supply fuzzy situation images with the demand fuzzy reference situation image for the intellectual management of the compliance of supply and demand in the health workforce market and to define the pair with a greater similarity (proximity) rate.

11.3. The methods for the recognition of fuzzy supply and demand images for MS

Thus, the statement and objective of the decision task related to the compliance of supply and demand are based on the management of situations using the determination of the proximity measure and similarity rate between the two fuzzy situations. As the measure of identifying the proximity rate of fuzzy real and reference situations, the determination of the fuzzy inclusion of situation $\tilde{S}_g$ in fuzzy situation $\tilde{V}_i$ can be used; and the determination of the degrees of fuzzy equality of $\tilde{S}_g$ and $\tilde{V}_i$ can be used [15–17]:

1. The fuzzy inclusion $\theta(\tilde{S}_g, \tilde{V}_i)$ of situation $\tilde{S}_g$ in fuzzy situation $\tilde{V}_i$ is defined as follows:

$$\begin{aligned}\theta(\tilde{S}_g, \tilde{V}_i) &= \&\, \theta(\mu_{S_g}(y), \mu_{V_i}(y)) = \underset{y \in Y}{\&} (\max(1 - \mu_{S_g}(y), \mu_{V_i}(y))) = \\ &= \min_{y \in Y} (\max(1 - \mu_{S_g}(y), \mu_{V_i}(y)))\end{aligned} \tag{11.5}$$

If the inclusion degree of situation $\tilde{S}_g$ in situation $\tilde{V}_i$ is not less than the fuzzy inclusion limit ψ, which is adopted in accordance with the management condition (for example, $\psi \in [0,6;1]$), that is, $\theta(\tilde{S}_g, \tilde{V}_i) \geq \psi$, then the situation $\tilde{S}_g$ is fuzzy included into the situation $\tilde{V}_i$, that is ($\tilde{S}_g \mathrel{\underset{\sim}{\subseteq}} \tilde{V}_i$). In other words, if the fuzzy value of the indices of the situation $\tilde{S}_g$ (the real values of the indices characterizing a candidate for the vacancy) is fuzzy included into the values of the indices of the situation $\tilde{V}_i$ (the reference values of the indices required from the applicant), then the situation $\tilde{S}_g$ is fuzzy included into the situation $\tilde{V}_i$.

To make decision, each alternate situation out of the sets of candidates applying to the vacancy (situations of the sets of vacancies) is compared to the degree of inclusion into the reference images, and the candidate with the highest value is selected based on the following statement:

$$\max_i \theta(\tilde{S}_g, \tilde{V}_i) = \max_i \left[\min_{y \in Y} (\max(1 - \mu_{S_g}(y), \mu_{V_i}(y))) \right], \; g = \overline{1, q}.$$

2. Fuzzy equality (equivalence) rate AS the measure of the similarity rate of random fuzzy situation is determined as follows. Assume that, ψ is adopted as a fuzzy equality rate of the two situations (for example, ψ∈[0,7; 1]), and if there are the

situations included into one another, i.e., $\tilde{S}_g \subsetapprox \tilde{V}_i$ and $\tilde{V}_i \subsetapprox \tilde{S}_g$, $g = \overline{1,q},\ i = \overline{1,k},\ g \neq k$, then situations $\tilde{S}_g$ and $\tilde{V}_i$ are considered to be approximately equal. Such similarity rate, so-called fuzzy equality situations, is calculated according to the following statement:

$$\mu(\tilde{S}_g,\tilde{V}_i) = \vee(\tilde{S}_g,\tilde{V}_i) \vee (\tilde{V}_i,\ \tilde{S}_g) = \&\,\mu(\mu_{S_g}(y),\ \mu_{V_i}(y)) =$$
$$= \min_{y\in Y}\left[\min\left(\max\left(1-\mu_{S_g}(y), \mu_{V_i}(y)\right),\ \max\left(\mu_{S_g}(y), 1-\mu_{V_i}(y)\right)\right)\right]. \tag{11.6}$$

when $\psi \in [0{,}7;1]$, if $\mu(\tilde{S}_g,\tilde{V}_i) \geq \psi$, the situations $\tilde{S}_g$ and $\tilde{V}_i$ are considered to be equally fuzzy, that is $\tilde{S}_g \approx \tilde{V}_i$.

11.4. Management methods on possible scenarios of the compliance of demand and supply for MS

Several possible scenarios can be available for the identification of the most acceptable pairs for “employer–MS” by their proximity rate out of the sets of the real images of the medical specialists and survey’s reference images [5, 6]:

Scenario 1. One vacancy (employer’s request) – one applicant (MS).

In this case, if the degree of fuzzy similarity (reference search image of the vacancy $\tilde{V}_i$ and real image of the applicant $\tilde{S}_g$) of the two situations is not less than the limit accepted by the employer on the based (11.6), then a hiring decision is made, (figure 11.1).

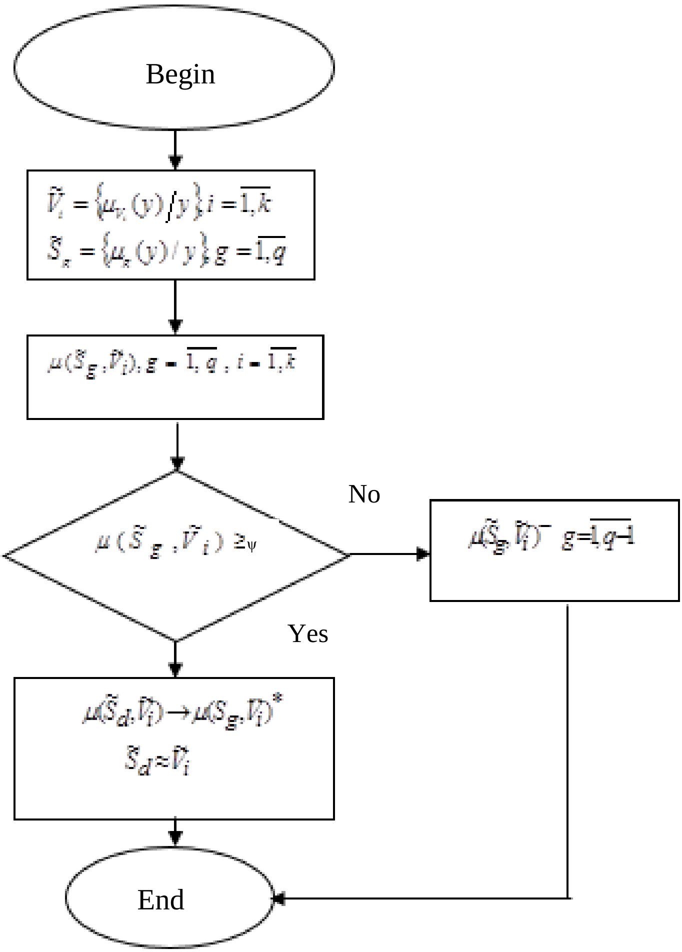

Figure 11.1. Block diagram of the decision-making process for scenario 1

Scenario 2. Several applicants (MS) respond to the employer's attitude in accordance with the accepted similarity measure of the two fuzzy situations. The latter ones create the subsets of fuzzy situations (alternates), out of which most eligible one should be selected.

In this case, the employer is offered the following decision methods:

Scenario 2.1. The proximity rates of reference and real situations are compared by the criteria describing the candidates for the vacancy and the decision on the most consistent situations is made.

Scenario 2.2. The task of decision making is reduced to the multi-criteria selection of better alternate, taking into account the relative importance criteria characterizing the applicants for the vacancy [11].

In this case, the decision is made in the following stages:

Stage 1.The situations that do not provide fuzzy inclusion or equality limit are "filtered", i.e., certain offer images do not participate in the next stages.

Stage 2. The relative importance ratios of the criteria and indicators are set [18, 19]. For this purpose, comparison matrix is established according to the diagonal, symmetry and transitiveness characteristics of the Saati schedule and matrix (table 11.1).

Table 11.1

9-point Saaty scale

Mark	**Linguistic assessment of pairwise comparison**
1	equivalence
3	moderate dominance
5	strong dominance
7	very strong dominance
9	the highest (extreme) dominance
2, 4, 6, 8	intermediate values between two neighbor scale values

If there are *n* indicators, then based on $n-1$ relations reflecting the pairwise comparison of these indicators, a matrix of pairwise comparisons based on such matrix characteristics as diagonality $(K_{ii} = 1,\ i = \overline{1,n})$, symmetry $K_{ij} = K_{ji}^{-1}$ and transitivity $K_{ig} \cdot K_{gj} = K_{ij}$ can be composed.

Using one of the four approaches proposed in [18, 19], the relative importance ratios are calculated.

In order to check whether there is any controversies within the statements of the employer and to detect the controversies, the maximum intrinsic value of the matrix – $\lambda_{\max}$, Consistency Index (CI) and Consistency Ratio (CR) are calculated. For this purpose, based on the method of multiplication of matrix by the vectors, a rough estimation method of consistency is referenced [18]. Multiplying the comparison matrix by the obtained decision vector (relative importance ratios), a new vector is obtained, and another vector is obtained by dividing its first component by the first component of the decision vector, its second component by the second component of the decision vector and so forth. λ_{max} (maximum or head special intrinsic value) is obtained by dividing the sum of this vector components by the number of components. The closer the value of λ_{max} to n, the more the result is considered to be agreed. The deviation from the consistency is called consistency index (CI) and this limit is determined by the following formula:

$$CI = (\lambda_{\max} - n)/(n-1) \tag{11.7}$$

Dividing the matrix consistency index by the Random consistency (RC) limit defines the consistency relation (CR):

$$CR = CI / RC. \tag{11.8}$$

According to [18], random consistency RC = 0,58 for n=3 dimensional matrix; RC =0,90 for n=4; RC=1,12 for n = 5 4; RC =1,24 for n= 6 and so forth.

If $CR \leq 0{,}1$, consistency limit is considered to be acceptable, otherwise expert values are required to be revised.

Step 3. The fuzzy similarity rate of the fuzzy real situations with the reference situations is defined based on indicators aggregation [17, 20]. This is performed by the following steps.

3.1. Establishing "convolution" of the indicators l_1, $l_2, \ldots, l_n$, $S = \{S_g\},\ g = \overline{1,q}$, the fuzzy similarity degree of fuzzy real situations with the fuzzy reference situations $V = \{V_i\}, i = \overline{1,k}$ according to L is set (table 11.2):

$$\mu_L\left(S_g\right) = \sum_{j=1}^{n} w_j \ \mu_{l_j}\left(S_g\right). \tag{11.9}$$

3.2. Establishing "convolution" of the indicators c_1, $c_2, \ldots, c_m$, $S = \{S_g\},\ g = \overline{1,q}$, the fuzzy similarity degree of fuzzy real situations with the fuzzy reference situations $V = \{V_i\}, i = \overline{1,k}$ according to C is set (table 11.2):

$$\mu_C(S_g) = \sum_{f=1}^{m} w_f \, \mu_{c_f}(S_g) \ . \tag{11.10}$$

3.3. Establishing "convolution" of the indicators u_1, $u_2, \ldots, u_p$, $S = \{S_g\},\ g = \overline{1,q}$, the fuzzy similarity degree of fuzzy real situations with the fuzzy reference situations $V = \{V_i\}, i = \overline{1,k}$ according to *U* is set (table 11.2):

$$\mu_U(S_g) = \sum_{\gamma=1}^{p} w_\gamma \mu_{u_\gamma}(S_g). \tag{11.11}$$

Table 11.2

The similarity degree of the fuzzy real situations $\tilde{S}_g,\ g=\overline{1,q}$
to the reference situations on the based criteria *L, C, U*

Fuzzy situation	$\varphi\left(\tilde{S}_g,\tilde{V}_i\right)$								
	$\varphi_L\left(\tilde{S}_g,\tilde{V}_i\right)$			$\varphi_C\left(\tilde{S}_g,\tilde{V}_i\right)$			$\varphi_U\left(\tilde{S}_g,\tilde{V}_i\right)$		
	l_1	…	l_n	c_1	…	c_m	u_1	…	u_p
$\tilde{S}_1$	$\varphi_{l_1}(S_1)$	…	$\varphi_{l_n}(S_1)$	$\varphi_{c_1}(S_1)$	…	$\varphi_{c_m}(S_1)$	$\varphi_{u_1}(S_1)$	…	$\varphi_{u_p}(S_1)$
…	…	…	…	…	…	…	…	…	…
$\tilde{S}_q$	$\varphi_{l_1}(S_q)$	…	$\varphi_{l_n}(S_q)$	$\varphi_{c_1}(S_q)$	…	$\varphi_{c_m}(S_q)$	$\varphi_{u_1}(S_q)$	…	$\varphi_{up}(S_q)$

$\varphi_L\left(\tilde{S}_g\right),\ g=\overline{1,q}$ $\qquad$ $\varphi_C\left(\tilde{S}_g\right),\ g=\overline{1,q}$ $\qquad$ $\varphi_U\left(\tilde{S}_g\right),\ g=\overline{1,q}$

3.4. Based on the obtained results and relative importance ratios w_L, w_C, w_U of the criteria *L, C, U*, the similarity degree of the fuzzy real situations to the reference situations is determined (table 11.3):

$$\mu_V\left(S_g\right)=\omega_L\cdot\mu_L(S_g)+\omega_C\cdot\mu_C(S_g)+\omega_U\cdot\mu_U(S_g)\,. \quad (11.12)$$

Table 11.3

The similarity degree of the fuzzy real situations $\tilde{S}_g,\ g=\overline{1,q}$ to the reference situations

Fuzzy real situation	$\varphi_W\left(\tilde{S}_g,\tilde{V}_i\right)$		
	$\varphi_L\left(\tilde{S}_g,\tilde{V}_i\right)$	$\varphi_C\left(\tilde{S}_g,\tilde{V}_i\right)$	$\varphi_U\left(\tilde{S}_g,\tilde{V}_i\right)$
$\tilde{S}_1$	$\varphi_L(S_1)$	$\varphi_C(S_1)$	$\varphi_U(S_1)$
...	...	...	...
$\tilde{S}_q$	$\varphi_L(S_q)$	$\varphi_C(S_q)$	$\varphi_U(S_q)$

$$\varphi_W\left(\tilde{S}_g,\tilde{V}_i\right)\quad g=\overline{1,q}$$

3.5. The fuzzy real situation with the highest value is selected:

$$\mu(S^*)=\max\left\{\mu_K(S_i),\ i=\overline{1,n}\right\}. \tag{11.13}$$

The selected fuzzy real situation is the image of the sought applicant with the highest degree of similarity to the reference vacancy image, and that can be regarded as the best decision.

Ssenario 2.3. The list of evaluation criteria is extended, and the input situations are re-defined (reexamined) and the recognition procedures are repeated. Block diagram of the decision-making process for scenario 2 is shown in figure 11.2.

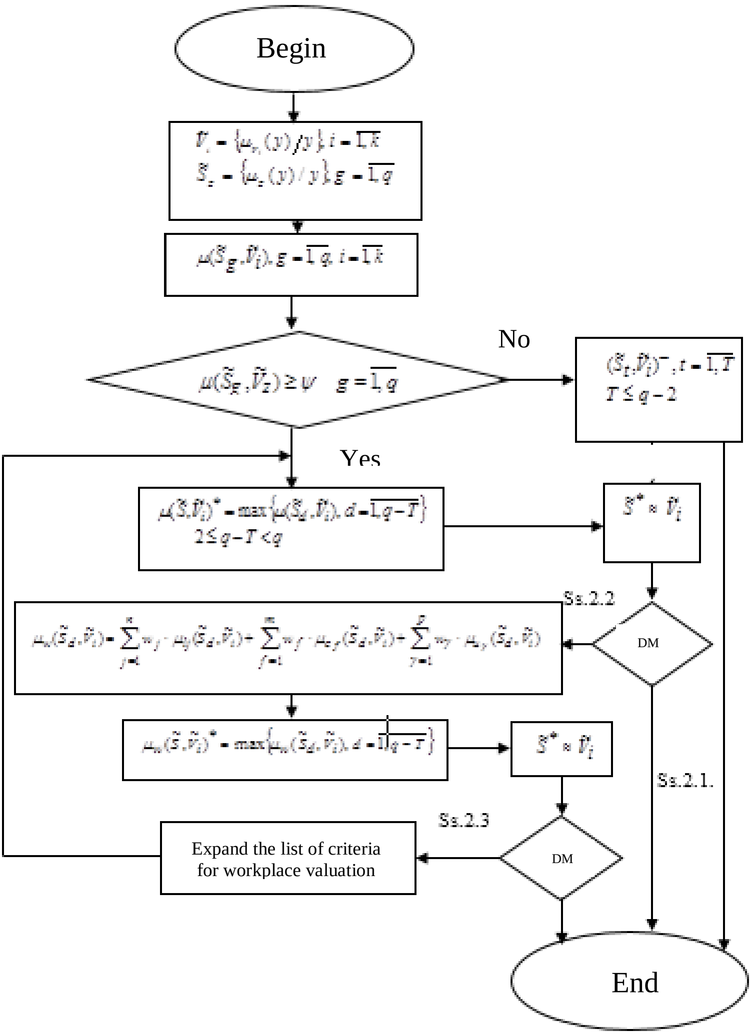

Figure 11.2. Block diagram of the decision-making process for scenario 2

Ssenario 3. Several employers are identified, who are interested in hiring one MS, i.e. “more fuzzy reference image – one fuzzy real image”.

In this case, there is an inverse task: a subset of fuzzy reference situations (alternatives) is presented, which is represented by the vacancies with the corresponding hiring conditions, among which a MS has to make a choice according to his/her preferences. According to the preferences of the latter, there can be the variants of scenario 3 listed below.

Scenario 3.1. The proximity rate of the claims of the MS with the criteria characterizing the conditions of employment shall be compared, and decision shall be made on the greatest coincidence of the degree of possession of the criteria.

Method for decision making. The task of decision making is reduced to the comparison of the similarities between real and standard situations in terms of the similarity rate of the conditions offered by employers and the claims of the applicant. The best vacancy has the greatest degree of similarity by the coincidence of the criteria that characterizes the conditions offered by employers, and the applicant’s claims. Thus, assume that:

$$\mu(\tilde{S}_d, \tilde{V}_z) = \max\left\{\mu(\tilde{S}_g, \tilde{V}_z),\ z = \overline{1, f},\ \ g = \overline{1, q}\right\}$$

$$V_z \in \left\{V_i,\ i = \overline{1, k}\right\}, \quad S_d \in \left\{S_g,\ g = \overline{1, q}\right\},\ 2 \le f < k.$$

In this case, the pair with the maximum value of the degree of fuzzy similarity situations is defined by the following formula:

$$\mu(\tilde{S}_d, \tilde{V}_\beta)^* = \max\left\{\mu_U(\tilde{S}_d, \tilde{V}_z),\ z = \overline{1, f}\right\}. \quad V_\beta \in \left\{\tilde{V}_z,\ z = \overline{1, f}\right\}.$$

The fuzzy reference situation is accepted as the best solution which is corresponding to the search pattern of the vacancy that has the greatest degree of fuzzy similarity with the applicant’s real pattern.

Scenario 3.2. The task of decisions making shall be reduced to the multi-objective task of choosing the best solution, taking into account the relative importance of the criteria that characterize workplaces.

Method for decision making. The task of decisions making shall be reduced to the multi-objective task of choosing the best solution, taking into account the relative importance of the indicators characterizing the preferences of the MS (*U*), expressed in terms of his/her requirements for a medicine-profile vacancy.

If $\omega_\gamma, \gamma = \overline{1, p}$ – the coefficients of the relative importance of the indicators characterizing the criterion *U*, then a fuzzy reference situation that has the greatest degree of fuzzy similarity with the applicant's real image is determined based on the following formula:

$$\mu(\tilde{S}_d, \tilde{V}_z)^* = \max\left\{\sum_{\gamma=1}^{p} w_\gamma \cdot \mu_u(\tilde{S}_d, \tilde{V}_z),\ z = \overline{1, f}\right\}.$$

The selected pair is taken as the best solution.

Scenario 3.3. The list of criteria for the workplace assessment shall be expanded, furthermore, the input situations shall be re-defined (re-examined) and the recognition procedure shall be repeated using formula (11.6).

Block diagram of the decision-making process for scenario 3 is shown in figure 11.3.

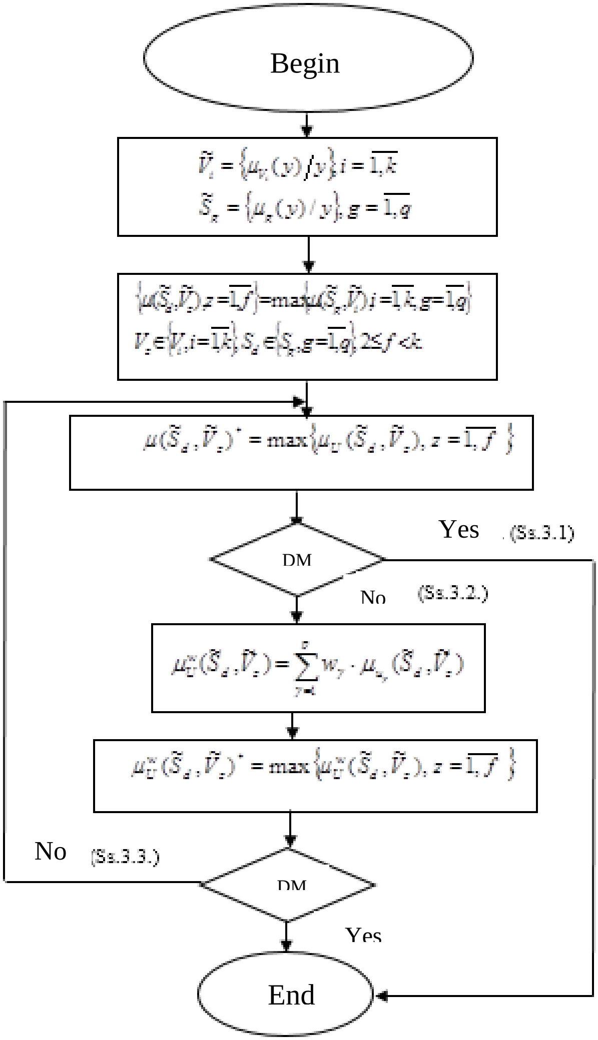

Figure 11.3. Block diagram of the decision-making process for scenario 3

11.5. Implementation of the management methods of supply and demand for MS

Assuming there are two vacancies $V = \{V_1, V_2\}$: V_1 – a pediatrician for private city clinic and V_2 – a pediatrician for the district hospital and 4 candidates applying to these vacancies - $S = \{S_1, S_2, S_3, S_4\}$. Solution stages of the recruitment of the 4 applicants to 2 vacancies are given below using the fuzzy equality method for the determination of the similarity degree of the fuzzy situations (note that, in the given issue, the vacancy is referred as the reference situation, and therefore, the similarity degrees obtained with the application of fuzzy inclusion of the situations and fuzzy equality methods provide the same result).

1st stage. Reference situation model of vacancies is established, that is, the system of indicators characterizing it is formed. Note that the data on the recruitment of medical specialists obtained from the sites [21–24] is used for the formation of the indicators system of the vacancies V_1 and V_2 (table 11.4).

Table 11.4

Indicators system of the vacancies V_1 and V_2

Vacancies	Criteria	Indicators	
		Conventional signs	linguistic variables
V_1	Personal Qualities L	l_1	sociable, friendly
		l_2	Responsible
		l_3	self developing
	Competence, knowledge and skills C	c_1	level of knowledge in accordance with the university diploma in "pediatrics"
		c_2	assured computer skills
		c_3	perfect knowledge of vocational skills
		c_4	presentation of competent writing skills
	Vacancy terms and requirements	u_1	at least 3 years practical experience
		u_2	re-qualification certificate

	U	u_3	Fluent Azerbaijani and Russian
V_2	Personal Qualities *L*	l_1	responsible, considerate
		l_2	Adaptive
	Competence, knowledge and skills C	c_1	level of knowledge in accordance with the university diploma in "pediatrics"
		c_2	perfect knowledge of vocational skills
	Vacancy terms and requirements *U*	u_1	living and working in villages and districts
		u_2	intense work schedule
		u_3	Fluent Azerbaijani (u_3)

2nd stage. To define the level of compliance of the applicants with the parameters that characterize the vacancy, the mathematical formalization of the indicators is set. For this purpose, the linguistic variables measured by verbal rating scale and grades are referred to. In this case, the levels of the linguistic variable, that is gradations vary according to the increase in the intensity of self-expression of the indicators. In our case, the gradations of the linguistic variables equal to 5 (e.g., excellent, good, normal, satisfactory, poor). Table11.5 shows 5-point scale of the index "sociable and friendly" and respective fuzzy values set defined in the interval [0; 1] [13, 25, 26].

Table 11.5

"Sociable and friendly" index fuzzyfication

“Sociable and friendly" index gradations	Linguistic value	Fuzzy set in the interval [0, 1]
1) very sociable and friendly	excellent	[0,95-1]
2) sociable and friendly	good	[0,8-0,94]
3) sociable	normal	[0,5-0,79]
4) almost sociable	satisfactory	[0,26-0,49]
5) quiet and unsociable	poor	[0,1-0,25]

3rd stage. Assuming the compliance of the applicants $S = \{S_1, S_2, S_3, S_4\}$ to the vacancy V_1 with the indicators characterizing this vacancy is assessed by the employer (expert) as below (table 11.6).

Table 11.6

Expert assessments of the applicants $S = \{S_1, S_2, S_3, S_4\}$ to the vacancy V_1

Indicators characterizing the vacancy V_1 \ Applicants to the vacancy V_1	S_1	S_2	S_3	S_4
Personal qualities(*L*)				
sociable, friendly (l_1)	excellent	good	good	normal
responsible(l_2)	good	good	good	good
self-developing (l_3)	good	good	normal	good
Competence, knowledge and skills (*C*)				
level of knowledge in accordance with the university diploma in "pediatrics" (c_1)	excellent	excellent	good	excellent
assured computer skills (c_2)	good	good	normal	good
perfect knowledge of vocational skills (c_3)	excellent	excellent	good	good
presentation of competent writing skills (c_4)	good	excellent	good	normal
Terms and requirements (*U*)				
at least 3 years practical experience (u_1)	good	good	excellent	excellent
re-qualification certificate (u_2)	good	good	excellent	excellent
Fluent Azerbaijani and Russian (u_3)	excellent	excellent	good	good

The compliance of the applicants with the indicators characterizing the vacancy V_1 is given in table 11.7.

Table 11.7. The compliance of the applicants with the indicators characterizing the vacancy V_1

Applicants / Indicators characterizing the vacancy V_1	S_1 $\mu_{L_j}(S_1) \to [0,1],\ j=\overline{1,3}$ $\mu_{C_f}(S_1) \to [0,1],\ f=\overline{1,4}$ $\mu_{U_\gamma}(S_1) \to [0,1],\ \gamma=\overline{1,3}$	S_2 $\mu_{L_j}(S_2) \to [0,1],\ j=\overline{1,3}$ $\mu_{C_f}(S_2) \to [0,1],\ f=\overline{1,4}$ $\mu_{U_\gamma}(S_2) \to [0,1],\ \gamma=\overline{1,3}$	S_3 $\mu_{L_j}(S_3) \to [0,1],\ j=\overline{1,3},$ $\mu_{C_f}(S_3) \to [0,1],\ f=\overline{1,4}$ $\mu_{U_\gamma}(S_3) \to [0,1],\ \gamma=\overline{1,3}$	S_4 $\mu_{L_j}(S_4) \to [0,1],\ j=\overline{1,3}$ $\mu_{C_f}(S_4) \to [0,1],\ f=\overline{1,4}$ $\mu_{U_\gamma}(S_4) \to [0,1],\ \gamma=\overline{1,3}$
Personal qualities(L)				
sociable, friendly (l_1)	0,97	0,88	0,82	0,65
responsible(l_2)	0,89	0,85	0,89	0,82
self-developing (l_3)	0,87	0,8	0,70	0,9
Competence, knowledge and skills (C)				
level of knowledge in accordance with the university diploma in "pediatrics" (c_1)	0,98	0,95	0,82	0,97
assured computer skills (c_2)	0,9	0,84	0,75	0,88
perfect knowledge of vocational skills (c_3)	0,95	0,97	0,80	0,82
presentation of competent writing skills (c_4)	0,82	0,95	0,9	0,70
Terms and requirements (U)				
at least 3 years practical experience (u_1)	0,90	0,94	0,97	0,96
re-qualification certificate (u_2)	0,82	0,82	0,97	0,95
Fluent Azerbaijani and Russian (u_3)	0,95	0,95	0,8	0,88

According to table 11.7 fuzzy real situations, i.e.fuzzy images of the applicants to the vacancy V_1 are formed:

$$\tilde{S}_1 = \{0,97/l_1; 0,89/l_2; 0,87/l_3; 0,98/c_1; 0,9/c_2; 0,95/c_3; 0,82/c_4; 0,9/u_1; 0,82/u_2; 0,95/u_3\}$$

$$\tilde{S}_2 = \{0,88/l_1; 0,85/l_2; 0,8/l_3; 0,95/c_1; 0,84/c_2; 0,97/c_3; 0,95/c_4; 0,94/u_1; 0,82/u_2; 0,95/u_3\}$$

$$\tilde{S}_3 = \{0,82/l_1; 0,89/l_2; 0,70/l_3; 0,82/c_1; 0,75/c_2; 0,8/c_3; 0,9/c_4; 0,97/u_1; 0,97/u_2; 0,8/u_3\}$$

$$\tilde{S}_4 = \{0,65/l_1; 0,82/l_2; 0,9/l_3; 0,97/c_1; 0,88/c_2; 0,82/c_3; 0,7/c_4; 0,96/u_1; 0,95/u_2; 0,88/u_3\}$$

Where the fuzzy reference image of the vacancy V_1 can be described as follows:

$$\tilde{V}_1 = \{0{,}98/l_1;\ 0{,}97/l_2;\ 0{,}98/l_3;\ 0{,}98/c_1;\ 0{,}97/c_2;\ 0{,}98/c_3;\ 0{,}98/c_4;\ 0{,}97/u_1;\ 0{,}98/u_2;\ 0.98/u_3\}$$

.

4th stage. Fuzzy similarity degree of the fuzzy real situations formed by the applicants to the reference situation is designated. For this purpose, using the formula (11.6), the equality degree of the fuzzy real and reference situations according to *L, C, U*.

4.1. Determination of the degree of fuzzy equality of reference and real situations according to personal qualities (*L*):

$$\varphi_L(\tilde{V}_1) = \{0{,}98/l_1; 0{,}97/l_2; 0{,}98/l_3\}$$
$$\varphi_L(\tilde{S}_1) = \{0{,}97/l_1; 0{,}89/l_2; 0{,}87/l_3\}$$
$$\varphi_L(\tilde{S}_2) = \{0{,}88/l_1; 0{,}85/l_2, 0{,}80/l_3\}$$
$$\varphi_L(\tilde{S}_3) = \{0{,}82/l_1; 0{,}89/l_2; 0{,}70/l_3\}$$
$$\varphi_L(\tilde{S}_4) = \{0{,}65/l_1; 0{,}82/l_2; 0{,}90 l_3\}$$

$$\mu_L(\tilde{V}_1, \tilde{S}_1) = \min(\max(1-0.98, 0.97), \max(0.98, 1-0.97))\ \&$$
$$\&\ \min(\max(1-0.97, 0.89), \max(0.97, 1-0.89))\ \&\ \min(\max(1-0.98, 0.87),$$
$$\max(0{,}98, 1-0.87)) = \min(0.97, 0.98)\ \&\ \min(0.89, 0.97)\ \&\ \min(0.87, 0.98) =$$
$$= 0.97\ \&\ 0.89\ \&\ 0.87 = 0.87$$

$$\mu_L(\tilde{V}_1, \tilde{S}_2) = \min(\max(1-0.98, 0.88), \max(0.98, 1-0.88))\ \&$$
$$\&\ \min(\max(1-0.97, 0.85), \max(0.97, 1-0.85))\ \&\ \min(\max(1-0.98, 0.80),$$
$$\max(0.98, 1-0.80)) = \min(0.88, 0.98)\ \&\ \min(0.85, 0.97)\ \&\ \min(0.80, 0.98) =$$
$$= 0.88\ \&\ 0.85\ \&\ 0.80 = 0.80$$

$$\mu_L(\tilde{V}_1, \tilde{S}_3) = \min(\max(1-0.98, 0.82), \max(0.98, 1-0.82))\ \&$$
$$\&\ \min(\max(1-0.97, 0.89), \max(0.97, 1-0.89))\ \&\ \min(\max(1-0.98, 0.70),$$
$$\max(0.98, 1-0.70)) = \min(0.82, 0.98)\ \&\ \min(0.89, 0.97)\ \&\ \min(0.70, 0.98) =$$
$$= 0.82\ \&\ 0.89\ \&\ 0.70 = 0.70$$

$$\mu_L(\tilde{V}_1, \tilde{S}_4) = \min(\max(1-0.98, 0.65), \max(0.98, 1-0.65))\ \&$$
$$\&\ \min(\max(1-0.97, 0.82), \max(0.97, 1-0.82)\ \&\ \min(\max(1-0.98, 0.90),$$
$$\max(0.98, 1-0.90)) = \min(0.65, 0.98)\ \&\ \min(0.82, 0.97)\ \&\ \min(0.90, 0.98) =$$
$$= 0.65\ \&\ 0.82\ \&\ 0.90 = 0.65$$

4.2. Determination of the degree of fuzzy equality of reference and real situations according to competence, knowledge and habits (*C*):

$$\varphi_C(\tilde{V}_1) = \{0.98/c_1; 0.97/c_2; 0.98/c_3;\ 0.98/c_4\}$$
$$\varphi_C(\tilde{S}_1) = \{0{,}98/c_1; 0{,}90/c_2; 0{,}95/c_3;\ 0.82/c_4\}$$
$$\varphi_C(\tilde{S}_2) = \{0{,}95/c_1; 0{,}84/c_2, 0{,}97/c_3;\ 0.95/c_4\}$$
$$\varphi_C(\tilde{S}_3) = \{0{,}82/c_1; 0{,}75/c_2; 0{,}80/c_3;\ 0.90/c_4\}$$
$$\varphi_C(\tilde{S}_4) = \{0{,}97/c_1; 0{,}88/c_2; 0{,}82/c_3;\ 0.70/c_4\}$$

$$\mu_C(\tilde{V}_1, \tilde{S}_1) = \min(\max(1-0.98, 0.98), \max(0.98, 1-0.98))\ \&$$
$$\&\ \min(\max(1-0.97, 0.90), \max(0.97, 1-0.90))\ \&\ \min(\max(1-0.98, 0.95),$$
$$\max(0.98, 1-0.95))\ \&\ \min(\max(1-0.98, 0.82), \max(0.98, 1-0.82)) =$$
$$= \min(0.98, 0.98)\ \&\ \min(0.90, 0.97)\ \&\ \min(0.95, 0.98)\ \&\ \min(0.90, 0.97) =$$
$$= 0.98\ \&\ 0.90\ \&\ 0.95\ \&\ 0.90 = 0.90$$

$$\mu_C(\tilde{V}_1,\tilde{S}_2) = \min(\max(1-0.98, 0.95), \max(0.98, 1-0.95))\ \&$$
$$\&\ \min(\max(1-0.97, 0.84), \max(0.97, 1-0.84))\ \&\ \min(\max(1-0.98, 0.97),$$
$$\max(0.98, 1-0.97))\ \&\ \min(\max(1-0.98, 0.95), \max(0.98, 1-0.95)) =$$
$$= \min(0.95, 0.98)\ \&\ \min(0.84, 0.97)\ \&\ \min(0.97, 0.98)\ \&\ \min(0.95,\ 0.98) =$$
$$= 0.95\ \&\ 0.84\ \&\ 0.97\ \&\ 0.95 = 0.84$$

$$\mu_C(\tilde{V}_1,\tilde{S}_3) = \min(\max(1-0.98, 0.82), \max(0.98, 1-0.82))\ \&$$
$$\&\ \min(\max(1-0.97, 0.75), \max(0.97, 1-0.75))\ \&\ \min(\max(1-0.98, 0.80),$$
$$\max(0.98, 1-0.80))\ \&\ \min(\max(1-0.98, 0.90), \max(0.98, 1-0.90)) =$$
$$= \min(0.82, 0.98)\ \&\ \min(0.75, 0.97)\ \&\ \min(0.80, 0.98)\ \&\ \min(0.90, 0.98 =$$
$$= 0.82\ \&\ 0.75\ \&\ 0.80\ \&\ 0.90 = 0.75$$

$$\mu_C(\tilde{V}_1,\tilde{S}_4) = \min(\max(1-0.98, 0.97), \max(0.98, 1-0.97))\ \&$$
$$\&\ \min(\max(1-0.97, 0.88), \max(0.97, 1-0.88))\ \&\ \min(\max(1-0.98, 0.82),$$
$$\max(0.98, 1-0.82))\ \&\ \min(\max(1-0.98, 0.70), \max(0.98, 1-0.70)) =$$
$$= \min(0.97, 0.98)\ \&\ \min(0.88, 0.97)\ \&\ \min(0.82, 0.98)\ \&\ \min(0.70, 0.98) =$$
$$= 0.97\ \&\ 0.88\ \&\ 0.82\ \&\ 0.70 = 0.70$$

4.3. Determination of the degree of fuzzy equality of reference and real situations according to the requirements and conditions of the vacancy (*U*):

$$\varphi_U(\tilde{V}_1) = \{0.97/u_1; 0.98/u_2; 0.98/u_3\}$$
$$\varphi_U(\tilde{S}_1) = \{0{,}90/u_1; 0{,}82/u_2; 0{,}95/u_3\}$$
$$\varphi_U(\tilde{S}_2) = \{0{,}94/u_1; 0{,}82/u_2, 0{,}95/u_3\}$$
$$\varphi_U(\tilde{S}_3) = \{0{,}97/u_1; 0{,}97/u_2; 0{,}80/u_3\}$$
$$\varphi_U(\tilde{S}_4) = \{0{,}96/u_1; 0{,}95/u_2; 0{,}88/u_3\}$$

$$\mu_U(\tilde{V}_1,\tilde{S}_1) = \min(\max(1-0.97, 0.90), \max(0.97, 1-0.90))\ \&$$
$$\&\ \min(\max(1-0.98, 0.82), \max(0.98, 1-0.82))\ \&\ \min(\max(1-0.98, 0.95),$$
$$\max(0.98, 1-0.95) = \min(0.90, 0.97)\ \&\ \min(0.82, 0.98)\ \&\ \min(0.95, 0.98) =$$
$$= 0.90\ \&\ 0.82\ \&\ 0.95 = 0.82$$

$$\mu_U(\tilde{V}_1,\tilde{S}_2) = \min(\max(1-0.97, 0.94), \max(0.96, 1-0.94))\ \&$$
$$\&\ \min(\max(1-0.98, 0.82), \max(0.98, 1-0.82))\ \&\ \min(\max(1-0.98, 0.95),$$
$$\max(0.98, 1-0.95) = \min(0.94, 0.96)\ \&\ \min(0.82, 0.98)\ \&\ \min(0.95, 0.98) =$$
$$= 0.94\ \&\ 0.82\ \&\ 0.95 = 0.82$$

$$\mu_U(\tilde{V}_1,\tilde{S}_3) = \min(\max(1-0.97, 0.97), \max(0.97, 1-0.97))\ \&$$
$$\&\ \min(\max(1-0.98, 0.97), \max(0.98, 1-0.97))\ \&\ \min(\max(1-0.98, 0.80),$$
$$\max(0.98, 1-0.80) = \min(0.97, 0.97)\ \&\ \min(0.97, 0.98)\ \&\ \min(0.80, 0.98) =$$
$$= 0.97\ \&\ 0.97\ \&\ 0.80 = 0.80$$

$$\mu_U(\tilde{V}_1,\tilde{S}_4) = \min(\max(1-0.97, 0.96), \max(0.97, 1-0.96))\ \&$$
$$\&\ \min(\max(1-0.98, 0.95), \max(0.98, 1-0.95))\ \&\ \min(\max(1-0.98, 0.88),$$
$$\max(0.98, 1-0.88) = \min(0.96, 0.97)\ \&\ \min(0.95, 0.98)\ \&\ \min(0.88, 0.98) =$$
$$= 0.96\ \&\ 0.95\ \&\ 0.88 = 0.88$$

4.4. The results of fuzzy equality rates of the candidates $\mu_L(\tilde{V}_1,\tilde{S}_i),\ i=\overline{1,4}$ for vacancy V_1 according to the parameters that characterize them are as follows:

- according to personal qualities (L):

$$\mu_L(\tilde{V}_1,\tilde{S}_1) = 0{,}87$$
$$\mu_L(\tilde{V}_1,\tilde{S}_2) = 0{,}80$$
$$\mu_L(\tilde{V}_1,\tilde{S}_3) = 0{,}70$$
$$\mu_L(\tilde{V}_1,\tilde{S}_4) = 0{,}65$$

– according to competence (*C*):

$$\mu_C(\tilde{V}_1, \tilde{S}_1) = 0{,}82$$
$$\mu_C(\tilde{V}_1, \tilde{S}_2) = 0{,}84$$
$$\mu_C(\tilde{V}_1, \tilde{S}_3) = 0{,}75$$
$$\mu_C(\tilde{V}_1, \tilde{S}_4) = 0{,}70$$

– according to vacancy requirements (U):

$$\mu_U(\tilde{V}_1, \tilde{S}_1) = 0{,}82$$
$$\mu_U(\tilde{V}_1, \tilde{S}_2) = 0{,}82$$
$$\mu_U(\tilde{V}_1, \tilde{S}_3) = 0{,}80$$

Based on the obtained results, the fuzzy similarity degree of the real situation to the reference situations, i.e., $\mu(\tilde{V}_1, \tilde{S}_g)$, $g = \overline{1, 4}$ is defined as follows:

$$\mu(\tilde{V}_1, \tilde{S}_1) = \mu_L(\tilde{V}_1, \tilde{S}_1) \,\&\, \mu_C(\tilde{V}_1, \tilde{S}_1) \,\&\, \mu_U(\tilde{V}_1, \tilde{S}_1) = 0{,}87 \,\&\, 0{,}82 \,\&\, 0{,}82 = 0{,}82,$$

$$\mu(\tilde{V}_1, \tilde{S}_2) = \mu_L(\tilde{V}_1, \tilde{S}_2) \,\&\, \mu_C(\tilde{V}_1, \tilde{S}_2) \,\&\, \mu_U(\tilde{V}_1, \tilde{S}_2) = 0{,}8 \,\&\, 0{,}4 \,\&\, 0{,}82 = 0{,}8,$$

$$\mu(\tilde{V}_1, \tilde{S}_3) = \mu_L(\tilde{V}_1, \tilde{S}_3) \,\&\, \mu_C(\tilde{V}_1, \tilde{S}_3) \,\&\, \mu_U(\tilde{V}_1, \tilde{S}_3) = 0{,}7 \,\&\, 0{,}75 \,\&\, 0{,}8 = 0{,}7,$$

$$\mu(\tilde{V}_1, \tilde{S}_4) = \mu_L(\tilde{V}_1, \tilde{S}_4) \,\&\, \mu_C(\tilde{V}_1, \tilde{S}_4) \,\&\, \mu_U(\tilde{V}_1, \tilde{S}_4) = 0{,}65 \,\&\, 0{,}7 \,\&\, 0{,}88 = 0{,}65.$$

Thus, comparative analysis of results shows that the candidate S_1 is the most suitable candidate for vacancy V_1 for all parameters.

5th stage. The results of the expert assessments of the compliance of the applicants with the indicators characterizing the vacancy V_2 are given in table 11.8.

Table 11.8

Linguistic values of the compliance of the applicants with the indicators characterizing the vacancy V_2

Applicants to the vacancy V_2 / Indicators characterizing the vacancy V_2	S_1	S_2	S_3	S_4
Personal qualities(L)				
sociable, friendly (l_1)	good	good	good	good
adaptable(l_2)	normal	good	normal	good
Competence, knowledge and skills (C)				
level of knowledge in accordance with the university diploma in "pediatrics" (c_1)	excellent	excellent	good	excellent
perfect knowledge of vocational skills (c_2)	excellent	excellent	good	good
Terms and requirements (U)				good
living and working in villages and districts (u_1)	good	good	normal	good
intense work scheduleif necessary(u_2)	normal	good	normal	good
Fluent Azerbaijani (u_3)	excellent	excellent	good	good

The compliance of the applicants with the indicators characterizing the vacancy V_2 is given in table 11.9.

Table 11.9

The compliance of the applicants with the indicators characterizing the vacancy V_2

Applicants to the vacancy V_2 / Indicators characterizing the vacancy V_2	S_1	S_2	S_3	S_4
Personal qualities(*L*)				
sociable, friendly (l_1)	0,85	0,9	0,88	0,86
adaptable(l_2)	0,6	0,92	0,75	0,94
Competence, knowledge and skills (*C*)				
level of knowledge in accordance with the university diploma in "pediatrics" (c_1)	0,97	0,96	0,85	0,96
perfect knowledge of vocational skills (c_2)	0,98	0,96	0,82	0,85
Terms and requirements (*U*)				
living and working in villages and districts (u_1)	0,8	0,9	0,75	0,88
intense work scheduleif necessary(u_2)	0,65	0,9	0,77	0,85
Fluent Azerbaijani (u_3)	0,96	0,96	0,85	0,9

Based on Table 11.9, fuzzy real images of the applicants to the vacancy V_2 are formed.

$$\tilde{S}_1 = \{0{,}85/l_1; 0{,}6/l_2; \ 0{,}97/c_1; 0{,}98/c_2; \ 0{,}8/u_1; 0{,}65/u_2; 0{,}96/u_3\}$$

$$\tilde{S}_2 = \{0{,}9/l_1; 0{,}92/l_2; \ 0{,}96/c_1; 0{,}96/c_2; \ 0{,}9/u_1; 0{,}9/u_2; 0{,}96/u_3\}$$

$$\tilde{S}_3 = \{0{,}88/l_1; 0{,}75/l_2; \ 0{,}85/c_1; 0{,}82/c_2; 0{,}75/u_1; 0{,}77/u_2; 0{,}85/u_3\}$$

$$\tilde{S}_4 = \{0{,}86/l_1; 0{,}94/l_2; 0{,}96/c_1; 0{,}85/c_2; 0{,}88/u_1; 0{,}85/u_2; 0{,}9/u_3\}$$

Fuzzy reference images of the vacancy V_2 can be described as:

$$\tilde{V}_2 = \{0{,}98/l_1;\ 0.99/l_2;\ 0{,}97/c_1;\ 0{,}98/c_2;\ 0{,}98/u_1;\ 0{,}97/u_2;\ 0{,}98/u_3\}$$

Based on the formula (11.6), fuzzy equality degrees of the fuzzy real and reference situations are calculated according to *L, C, U.*

5.1. Determination of the degree of fuzzy equality of reference and real situations according to personal qualities (*L*):

$$\varphi_L(\tilde{V}_2) = \{0{,}98/l_1; 0{,}99/l_2\}$$
$$\varphi_L(\tilde{S}_1) = \{0{,}85/l_1; 0{,}60/l_2\}$$
$$\varphi_L(\tilde{S}_2) = \{0{,}90/l_1; 0{,}92/l_2\}$$
$$\varphi_L(\tilde{S}_3) = \{0{,}88/l_1; 0{,}75/l_2\}$$
$$\varphi_L(\tilde{S}_4) = \{0{,}86/l_1; 0{,}94/l_2\}$$

$$\mu_L(\tilde{V}_2, \tilde{S}_1) = \min(\max(1-0.98, 0.85), \max(0.98, 1-0.85))\ \&$$
$$\&\ \min(\max(1-0.99, 0.60), \max(0.99, 1-0.60)) = \min(0.85, 0.98)\ \&$$
$$\&\ \min(0.60, 0.99) = 0.85\ \&\ 0.60 = 0.60$$

$$\mu_L(\tilde{V}_2, \tilde{S}_2) = \min(\max(1-0.98, 0.90), \max(0.98, 1-0.90))\ \&$$
$$\&\ \min(\max(1-0.99, 0.92), \max(0.99, 1-0.92)) = \min(0.90, 0.98)\ \&$$
$$\&\ \min(0.92, 0.99) = 0.90\ \&\ 0.92 = 0.90$$

$$\mu_L(\tilde{V}_2, \tilde{S}_3) = \min(\max(1-0.98, 0.88), \max(0.98, 1-0.88))\ \&$$
$$\&\ \min(\max(1-0.99, 0.75), \max(0.99, 1-0.75) = \min(0.88, 0.98)\ \&$$
$$\&\ \min(0.75, 0.99) = 0.88\ \&\ 0.75 = 0.75$$

$$\mu_L(\tilde{V}_2,\tilde{S}_4) = \min(\max(1-0.98, 0.86), \max(0.98, 1-0.86)) \,\&$$
$$\& \min(\max(1-0.99, 0.94), \max(0.99, 1-0.94) = \min(0.86, 0.98) \,\&$$
$$\& \min(0.94, 0.99) = 0.86 \,\&\, 0.94 = 0.86$$

5.2. Determination of the degree of fuzzy equality of etalon and real situations according to competence, knowledge and habits (*C*):

$$\varphi_C(\tilde{V}_2) = \{0.97/c_1; 0.98/c_2\}$$
$$\varphi_C(\tilde{S}_1) = \{0,97/c_1; 0,98/c_2\}$$
$$\varphi_C(\tilde{S}_2) = \{0,96/c_1; 0,96/c_2\}$$
$$\varphi_C(\tilde{S}_3) = \{0,85/c_1; 0,82/c_2\}$$
$$\varphi_C(\tilde{S}_4) = \{0,96/c_1; 0,85/c_2\}$$

$$\mu_C(\tilde{V}_2,\tilde{S}_1) = \min(\max(1-0.97, 0.97), \max(0.97, 1-0.97)) \,\&$$
$$\& \min(\max(1-0.98, 0.98), \max(0.98, 1-0.98)) = \min(0.97, 0.97) \,\&$$
$$\& \min(0.98, 0.98) = 0.97 \,\&\, 0.98 = 0.97$$

$$\mu_C(\tilde{V}_2,\tilde{S}_2) = \min(\max(1-0.97, 0.96), \max(0.97, 1-0.96)) \,\&$$
$$\& \min(\max(1-0.98, 0.96), \max(0.98, 1-0.96)) = \min(0.96, 0.97) \,\&$$
$$\& \min(0.96, 0.98) = 0.96 \,\&\, 0.96 = 0.96$$

$$\mu_C(\tilde{V}_2,\tilde{S}_3) = \min(\max(1-0.97, 0.85), \max(0.97, 1-0.85)) \,\&$$
$$\& \min(\max(1-0.98, 0.82), \max(0.98, 1-0.82)) = \min(0.85, 0.97) \,\&$$
$$\& \min(0.96, 0.98) = 0.85 \,\&\, 0.96 = 0.85$$

$$\mu_C(\tilde{V}_2,\tilde{S}_4) = \min(\max(1-0.97, 0.96), \max(0.97, 1-0.96)) \,\&$$
$$\& \min(\max(1-0.98, 0.85), \max(0.98, 1-0.85)) = \min(0.96, 0.97) \,\&$$
$$\& \min(0.85, 0.98) = 0.96 \,\&\, 0.85 = 0.85$$

5.3. Determination of the degree of fuzzy equality of reference and real situations according to the requirements and conditions of the vacancy (*U*):

$$\varphi_U(\tilde{V}_2) = \{0.98/u_1; 0.97/u_2; 0.98/u_3\}$$
$$\varphi_U(\tilde{S}_1) = \{0{,}80/u_1; 0{,}65/u_2; 0{,}96/u_3\}$$
$$\varphi_U(\tilde{S}_2) = \{0{,}90/u_1; 0{,}90/u_2, 0{,}96/u_3\}$$
$$\varphi_U(\tilde{S}_3) = \{0{,}75/u_1; 0{,}77/u_2; 0{,}85/u_3\}$$
$$\varphi_U(\tilde{S}_4) = \{0{,}88/u_1; 0{,}85/u_2; 0{,}90/u_3\}$$

$$\mu_U(\tilde{V}_2, \tilde{S}_1) = \min(\max(1-0.98, 0.80), \max(0.98, 1-0.80))\ \&$$
$$\&\ \min(\max(1-0.97, 0.65), \max(0.97, 1-0.65))\ \&\ \min(\max(1-0.98, 0.96),$$
$$\max(0.98, 1-0.96) = \min(0.80, 0.98)\ \&\ \min(0.65, 0.97)\ \&\ \min(0.96, 0.98) =$$
$$= 0.80\ \&\ 0.65\ \&\ 0.96 = 0.65$$

$$\mu_U(\tilde{V}_2, \tilde{S}_2) = \min(\max(1-0.98, 0.90), \max(0.98, 1-0.90))\ \&$$
$$\&\ \min(\max(1-0.97, 0.90), \max(0.97, 1-0.90))\ \&\ \min(\max(1-0.98, 0.96),$$
$$\max(0.98, 1-0.96) = \min(0.90, 0.98)\ \&\ \min(0.90, 0.97)\ \&\ \min(0.96, 0.98) =$$
$$= 0.90\ \&\ 0.90\ \&\ 0.96 = 0.90$$

$$\mu_U(\tilde{V}_2, \tilde{S}_3) = \min(\max(1-0.98, 0.75), \max(0.98, 1-0.75))\ \&$$
$$\&\ \min(\max(1-0.97, 0.77), \max(0.97, 1-0.77))\ \&\ \min(\max(1-0.98, 0.85),$$
$$\max(0.98, 1-0.85) = \min(0.75, 0.98)\ \&\ \min(0.77, 0.97)\ \&\ \min(0.85, 0.98) =$$
$$= 0.75\ \&\ 0.77\ \&\ 0.85 = 0.75$$

$$\mu_U(\tilde{V}_2, \tilde{S}_4) = \min(\max(1-0.98, 0.88), \max(0.98, 1-0.88))\ \&$$
$$\&\ \min(\max(1-0.97, 0.85), \max(0.97, 1-0.85))\ \&\ \min(\max(1-0.98, 0.90),$$
$$\max(0.98, 1-0.90) = \min(0.88, 0.98)\ \&\ \min(0.85, 0.97)\ \&\ \min(0.90, 0.98) =$$
$$= 0.88\ \&\ 0.85\ \&\ 0.90 = 0.85$$

5.4. The results of fuzzy equality degrees of the candidates $S=\{S_1,S_2,S_3,S_4\}$ for vacancy V_2 according to the parameters that characterize them are as follows:

- according to personal qualities (L):

$$\mu_L(\tilde{V}_2,\tilde{S}_1)=0{,}60$$
$$\mu_L(\tilde{V}_2,\tilde{S}_2)=0{,}90$$
$$\mu_L(\tilde{V}_2,\tilde{S}_3)=0{,}75$$
$$\mu_L(\tilde{V}_2,\tilde{S}_4)=0{,}86$$

– according to competence (*C*):

$$\mu_C(\tilde{V}_2,\tilde{S}_1)=0{,}97$$
$$\mu_C(\tilde{V}_2,\tilde{S}_2)=0{,}96$$
$$\mu_C(\tilde{V}_2,\tilde{S}_3)=0{,}82$$
$$\mu_C(\tilde{V}_2,\tilde{S}_4)=0{,}85$$

– according to vacancy requirements (*U*):

$$\mu_U(\tilde{V}_2,\tilde{S}_1)=0{,}65$$
$$\mu_U(\tilde{V}_2,\tilde{S}_2)=0{,}90$$
$$\mu_U(\tilde{V}_2,\tilde{S}_3)=0{,}75$$
$$\mu_U(\tilde{V}_2,\tilde{S}_4)=0{,}85$$

5.5. Based on the obtained results, the fuzzy similarity degree of the real situation to the reference situations, i.e., $\mu(\tilde{V}_2,\tilde{S}_g),\ g=\overline{1,4}$ is defined as follows:

$$\mu(\tilde{V}_2,\tilde{S}_1)=\mu_L(\tilde{V}_2,\tilde{S}_1)\,\&\,\mu_C(\tilde{V}_2,\tilde{S}_1)\,\&\,\mu_U(\tilde{V}_2,\tilde{S}_1)=0{,}6\,\&\,0{,}97\,\&\,0{,}65=0{,}6\,.$$

$$\mu(\tilde{V}_2,\tilde{S}_2)=\mu_L(\tilde{V}_2,\tilde{S}_2)\,\&\,\mu_C(\tilde{V}_2,\tilde{S}_2)\,\&\,\mu_U(\tilde{V}_2,\tilde{S}_2)=0{,}9\,\&\,0{,}96\,\&\,0{,}9=0{,}9\,.$$

$$\mu(\tilde{V}_2,\tilde{S}_3)=\mu_L(\tilde{V}_2,\tilde{S}_3)\,\&\,\mu_C(\tilde{V}_2,\tilde{S}_3)\,\&\,\mu_U(\tilde{V}_2,\tilde{S}_3)=0{,}75\,\&\,0{,}82\,\&\,0{,}75=0{,}75\,.$$

$$\mu(\tilde{V}_2,\tilde{S}_4)=\mu_L(\tilde{V}_2,\tilde{S}_4)\,\&\,\mu_C(\tilde{V}_2,\tilde{S}_4)\,\&\,\mu_U(\tilde{V}_2,\tilde{S}_4)=0{,}86\,\&\,0{,}85\,\&\,0{,}88=0{,}85\,.$$

The obtained results are provided in table 11.10.

Table 11.10

Fuzzy similarity degrees $\mu(\tilde{V}_1,\tilde{S}_g),\ g=\overline{1,4}$ and $\mu(\tilde{V}_2,\tilde{S}_g),\ g=\overline{1,4}$

Applicants	$\mu(\tilde{V}_1,\tilde{S}_g),\ g=\overline{1,q}$	$\mu(\tilde{V}_2,\tilde{S}_g),\ g=\overline{1,q}$
S_1	**0,82**	0,6
S_2	0,8	**0,9**
S_3	0,7	0,75
S_4	0,65	0,85

6th stage. Pending case scenario corresponds to 2.1, i.e., fuzzy reference situation V_1 and real situations $\tilde{S}_1,\tilde{S}_2,\tilde{S}_3$ are fuzzy similar and real situations and the closest one to the real image is the real situation S_1 ($\mu(V_1,S_1)=0.82$). Fuzzy reference situation V_1 and fuzzy real situation S_4 arenot fuzzy equal, and the equality degree of this "pair" is less than the fuzzy equality limit, that is $\mu(V_1,S_4)=0{,}65<0{,}7$.

Fuzzy reference situation V_2 and real situations $\tilde{S}_2,\tilde{S}_3,\tilde{S}_4$ are fuzzy similar, and the closest one to the real image is the real situation S_2 ($\mu(V_2,S_2)=0.9$). The pair of the images V_2 and S_1 are not fuzzy equal, that is $\mu(V_2,S_1)=0{,}6<0{,}7$.

7th stage. Assuming an employer is interested in taking into account the relative superiority of the indicators in selecting the most appropriate applicants. In this case, the decision is made in accordance with the scenario 2.2 (real situations S_4 and S_1 for the vacancies V_1 and V_2, respectively, are not considered at this stage).

Relative importance ratios are determined by referring to Table 11.1 based on the following expert assessment about the relative superiority of the criteria *L*, *C* and *U* characterizing the vacancy V_1 and the relative superiority of the certain indicators characterizing them:

- "competence, knowledge and skills (*C*) are much more important compared to personal qualities (*L*), and less important compared to terms and requirements (*U*)";

- "responsible (l_2) is considerably much more important compared to sociable and friendly (l_1), self-developing (l_3)";

- "level of knowledge in accordance with the university diploma (c_1) and perfect knowledge of vocational skills (c_2) are noticeably much more important compared to assured computer skills (c_2) and presentation of competent writing skills (c_4)"

- "minimum 3 years practical experience (u_1) is significantly more important compared to re-qualification certificate (u_2) and Fluent Azerbaijani and Russian language skills (u_3)".

Referring to the formulas (11.7) – (11.8), no contradiction is identified in the expert statements. The obtained results are given in table 11.11.

Table 11.11

Crite-ria	Criterion impor-tance ratios	Indi-cators	Indicators importance ratios	S_1 $\mu_{L_j}(S_1)\to[0,1], j=\overline{1,4}$, $\mu_{C_f}(S_1)\to[0,1], f=\overline{1,3}$, $\mu_{U_\gamma}(S_1)\to[0,1], \gamma=\overline{1,3}$	S_2 $\mu_{L_j}(S_2)\to[0,1], j=\overline{1,4}$, $\mu_{C_f}(S_2)\to[0,1], f=\overline{1,3}$, $\mu_{U_\gamma}(S_2)\to[0,1], \gamma=\overline{1,3}$	S_3 $\mu_{L_j}(S_3)\to[0,1], j=\overline{1,4}$, $\mu_{C_f}(S_3)\to[0,1], f=\overline{1,3}$ $\mu_{U_\gamma}(S_3)\to[0,1], \gamma=\overline{1,3}$
L	0,077	l_1	0,07	0,97	0,88	0,82
		l_2	0,465	0,89	0,85	0,89
		l_3	0,465	0,87	0,8	0,70
C	0,693	c_1	0,4166	0,98	0,95	0,82
		c_2	0,4166	0,9	0,84	0,75
		c_3	0,0834	0,95	0,97	0,80
		c_4	0,0834	0,82	0,95	0,9
U	0,23	u_1	0,714	0,90	0,94	0,97
		u_2	0,143	0,82	0,82	0,97
		u_3	0,143	0,95	0,95	0,8

8th stage. Based on the formulas (11.10) – (11.12), the degree of similarity of the real images S_1, S_2, S_3 and the reference image V_1 by L, C, U is determined:

$$\mu_L\left(\tilde{S}_g\right) = \sum_{j=1}^{3} \mu_{l\,j}(S_g) \cdot w_{l_j},$$

$$\mu_C(\tilde{S}_g) = \sum_{f=1}^{4} \mu_{c_f}(S_g) \cdot w_{c_f},$$

$$\mu_U(\tilde{S}_g) = \sum_{\gamma=1}^{3} \mu_{u_\gamma}(S_g) \cdot w_{u_\gamma}.$$

The results are given in table 11.12.

Table 11.12

Similarity degree of the real images by *L, C, U*

	Criteria	Criterion importance ratios	$\tilde{S}_1$ $\mu_L(S_1) \to [0,1]$ $\mu_C(S_1) \to [0,1]$ $\mu_U(S_1) \to [0,1]$	$\tilde{S}_2$ $\mu_L(S_2) \to [0,1]$ $\mu_C(S_2) \to [0,1]$ $\mu_U(S_2) \to [0,1]$	$\tilde{S}_3$ $\mu_L(S_3) \to [0,1]$ $\mu_C(S_3) \to [0,1]$ $\mu_U(S_3) \to [0,1]$
V_1	*L*	0,077	0,88	0,83	0,8
	C	0,693	0,93	0,91	0,8
	U	0,23	0,9	0,92	0,95

9th stage. Based on the formula (11.13), the degree of similarity of the applicants to the vacancy V_1 is determined:

$$\mu(V_1, S_i) = \mu_L(S_i) \cdot w_L + \mu_C(S_i) \cdot w_C + \mu_U(S_i) \cdot w_U.$$

The results are given in Table 11.13.

Table 11.13

The the degree of similarity of the applicants to the vacancy V_1

	$\tilde{S}_1$ $\mu(V_1, S_1) \to [0,1]$	$\tilde{S}_2$ $\mu(V_1, S_2) \to [0,1]$	$\tilde{S}_3$ $\mu(V_1, S_3) \to [0,1]$
$\mu(\tilde{V}_1, \tilde{S}_g)$	0,919	0,906	0,834

Thus, taking into account the importance ratios of the indicators, the real image of the applicant S_1 to the vacancy V_1 has the highest similarity degree to the reference image of the vacancy, and can be considered as the best decision.

Similarly, taking into account importance ratios of indicators, the best applicant for the vacancy V_2 is identified.

The proposed method is one of the support options for employers to make more justified decisions in the recruitment to the vacancies by complying the demand and supply of MS. This issue can be solved by considering the mandatory, optional, insignificance of the qualifications characterizing the vacancy [27]; by reducing the issue to collective decision [28]; by reducing the decision-making process to the issue of multi-criterion decision-making considering the competence of the participants in the subject matter [29, 30]. The importance of such support is conditioned by a number of factors, such as the dynamics of medical knowledge, the deepening of specialization, the unequal geographical and territorial distribution of health workforce, and therefore, the differing requirements for them, the high cost of training the qualified staff, increase in the value of healthcare workforces depending on their experience, increased demand for medical specialists in exchange for the tendency to decrease the supply and so on. Under these conditions, the modern employer must adapt his/her decisions to the changing management situations. Additionally, today, the number of the decisions to be made in uncertainty and non-standard situations, at all levels of management, has significantly increased. Since the human resources is the key determinant for the competitiveness of organization, it is strategically important to support the decision related to the staff and its intellectual potential.

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GLOSSARY

1. Personal medical record (PMR) is any record, relating to the health of a certain man and executed by a certain person.

2. Electronic personal medical record (EPMR) is any medical record stored on an electronic carrier. EPMR is tied to the certain electronic depository and characterized the moment of placing in this depository.

3. Electronic medical document (EMD) is an electronic medical personal record, passing the stage of signing the authorized person fully responsible for his maintenance, and being legally a meaningful medical document possessing properties of constancy and integrity.

4. Electronic medical map (EMM) is a totality of the electronic personal medical records (EPMR), related to one man, collected, kept and used within the framework of one medical organization. A term of EMM is the analogue of international term of EMR. In accordance with the type of medical organization it is possible to talk about:
The electronic ambulatory medical map for out-patient's clinics, policlinics, diagnostic centers, dispensaries, policlinic separations of permanent establishments or specialized medical centers, private doctors, commercial laboratories of and others.
Distinguishing an electronic ambulatory medical map and electronic medical map of in-patient is conditional. These terms are brought for correlation with existing ones. It is important to underline that complex medical organization can conduct the single electronic medical map of a patient without dividing it into stationary and ambulatory.

5. Integrated electronic medical map (IEMM) is a totality of the electronic personal medical records (EPMR), related to one man, collected and used by a few medical organizations. A term of IEMM is the analogue of international term of EHR (Electronic Health Record). In respect of storage of IEMM, the included electronic personal medical records (EPMR), can be kept both centralized and up-diffused (in different medical organizations). At the up-diffused storage access to separate EPMR entering in IEMM goes through the centralized index, containing information about the place of storage and method of access to every EPMR. The integrated electronic medical map can be created by a group of medical organizations, by a management organ of health care of region or even at national level. Method of management of IEMM, storages of information in it, right for access and standards of information exchange and inerportability must be specified by organizations using IEMM or by the organs of management of health care creating IEMM. General requirements to IEMM must be set forth in a separate national standard.

6. Personal electronic medical map (PEMM) is a totality of the electronic personal medical records (EPMR) recievced from different sources and related to one person who carries out their collection and management, and also determines the rights for their access. A term of PEMM is the analogue of international term of PHR (Personal Health Record). Storage of PEMM can be implemented by its proprietor on own electronic carriers (devices of flash drive of and other) or in the specialized depositories via the Internet or other communication channels. In the latter case, storage and service of conducting and management of PEMM is carried out by the specialized provider on the basis of the agreement celled with a proprietor of PEMM. General requirements to the providers of PEMM and service provided by them, and also to the management systems of PEMM on the personal electronic carriers must be set forth in a separate national standard.

7. Electronic medical archive (EMA) is an electronic depository of data, containing the electronic medical maps

(EMA) of patients of one medical organization and other sets of data and programs (classifiers and reference books, lists of patients and employees, means of navigation, search, visualization, interpretation, verifications of integrity and electronic-digital signature) necessary for the full functioning of the management systems of electronic medical maps in this medical organization.

8. Integrated electronic medical archive (IEMA) is an electronic depository of data, containing the IEMM collected and used by a few medical organizations, and also other sets of data and programs, necessary for sharing of stored IEMA. IEMA is created by the group of medical organizations for sharing or by management organ of health care for jurisdiction to him organizations. Storage of information within the framework IEMA can be centralized or up-diffused. In last case access to information of IEMK of patients comes true through the centralized index, being part of IEMA. Requirements and rules of functioning of IEMA, rights for access and standards of informative exchange, are set by medical organizations, together leading IEMA or management organ by a health protection his creating. General requirements to IEMA must be set forth in a separate national standard.

9. Personal electronic medical archive (PEMA) is an electronic depository of data, containing the PEMM, and also other sets of data, programs and services, necessary for collection, conduct and management of PEMA from the side of their proprietors. PEMA created by a certain provider for a grant to the persons of services in a conduct, safe storage and management their personal PEMA. Management facilities, included in the complement of PEMA, must envisage possibility of grant of rights access to PEMA or her part to the medical workers, organizations or another persons, at discretion of proprietor PEMA. Mutual relations between a proprietor PEMA and provider of PEMA are set on the basis of agreement (agreements). Rules of functioning of PEMA, right and duties, standards of electronic exchange users, the requirements of safety are set by a provider in accordance with a current legislation. General requirements to PEMA must be set forth in a separate national standard.

10. System of conducting electronic medical maps (SCEMM) is a set of computer programs, organizational and technical documentation, and also services of the accompaniment and support intended for collection and use of information included in the complement of electronic medical maps (including integrated and personal). Traditional term a "electronic hospital chart" is the analogue of SCEMM. The concept of SCEMM includes facilities allowing to the users to co-operate with the information contained in EMA, IEMA, PEMA.

11. Medical organizations – in this document, are the health protections directly carrying out ambulatory-policlinic, stationary and/or quick medicare of population.

12. **Electronic health (e-health)** is a complex of political, legislative, organizational, technical, financial and other measures and actions, providing application of information and communication technologies of the realization of aims and tasks of the health protection system.

13. Quality of medicare – totality of descriptions, reflecting the timeliness of providing of medicare, rightness of choice of methods of prophylaxis, diagnostics, treatment and rehabilitation at providing medicare, degree of achievement of the pre-arranged result.

14. Clinical competence – a capture of clinical knowledge and acquisition of clinical abilities at sufficient level, including their communicative, clinical and technical the components up to the certain term of education, in particular to the moment of completion of high medical education.

15. Medical activity – professional activity on providing medicare, realization of medical examinations, physical examinations and medical examinations, sanitary-epidemiological (prophylactic) implementations and professional activity related to transplantation of organs and (or) cells, appealing for donor blood and (or) its components for medical aims.

16. Medical informatics – an area of science that studies the storage, extraction and rational use of medical information through IT. The rapid development of medical informatics is obliged to considerable progress in area of computer and communication technologies.

17. Medical information system (MIS) – a document management system for medical and preventive institutions, which combines medical DSS, EMR of patients, medical research data in digital form, patient monitoring data from medical devices, communication tools between employees, and financial and administrative data.

18. Clinical information system – collects, stores, searches and transmits clinic information related to health.

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