Internet of Things: Modern Paradigm of Health Care

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***Abstract*—Some results of Data Mining of scientific publication activity in Scopus database and Text Big Data analytics using API access to Google about Information transformation are presented. The whole ecosystem of Internet of Health and its place within Internet of Things are described. System analysis is given about: Big Data market in Health Care, ways of Medical Information Systems development, and the direction of hospitals transition to new condition based on three "whales" (hybrid Cloud computing, supercomputer and data center). The Internet of Things ecosystem foregrounds some important aspects related to gerontology, genetics, biorhythmology, and gravitational biology. Sociological understanding of people's role in formation of the new high IT dependence reality allows to determine the main vectors of farsighted forecast. The technological evolution can be described as subsequent stages: distribution of IT – automation – Digital transformation and Internet of Things – Big Data analytics – Artificial Intelligence solutions – people connection to Augmented Reality – Context-as-A-Service – NBIC- and GRAIN-technologies – Humanity Plus. The essence of concept "patient" is changing. Patient transforms into an e-patient (all records about patient have been digitized) and then into Internet-patient with monitoring of health parameters within the Internet of Things surrounding people. Getting Augmented Reality patient is becoming a Digital patient. Augmented Reality methods are already being developed to treat patients. Medicine as part of social structure becomes more diffuse, covering common space of Internet of Things. Medical culture acquires a new value for society. Five measures for successful transformation of Health Care in Russia are recommended in the article.**

I. Introduction. Ecosystem for Health

Internet of Things (IoT) is the future of medicine. IoT is a broad term referring to Internet-connected technology. Internet of Health (IoH) is more specific definition of IoT in medicine (or Internet of Health Care Things). This refers to Internet-connected technology that applies to the Health Care industry. The term IoT has been proposed first by American scientist Peter Lewis in 1985. The idea of IoT has become popular since 1999 due to efforts of professor of MIT Kevin Ashton who described the IoT concept. Communication of all items and objects within a common network has become a reality in 2006 due to appearance of Cloud computing that is characterized by computational elasticity.

The idea of IoT comes from the last century. John McCarthy and Joseph Licklider were the first who proposed in 1960s to use computing resources as utilities (public service) like city water or electricity. Today the idea of IoT is reinforced by all necessary technical capabilities. All items, things, devices and objects possibly could be connected to Internet, forming IoT ecosystem as a new environment for society. The impact of IoT ecosystem on society, economy, Health Care is revolutionary. Both aspects of IoT ecosystem – technical and ethical – require the development of approaches and risk assessments.

American scientist Alvin Toffler was the most fundamental founder of the ideology of Information era [1]. Toffler described three periods of human history, three historical

"waves". The First wave had been agricultural, when society values related to land owning. The Second wave has been industrial. Society values related to obtaining and processing of natural resources. The Third wave is current. Toffler called it Informational. Society values are related to Information governance. This is the new technological order which has been described in detail by Toffler in 1980, both aspects: material world as well as social relationships and Health Care [1].

The scientific publication activity with mention of IoT development is the good indicator for this topic. The citation of IoT in Scopus database (Fig. 1) has sharply increased since 2010. The appearance of first citation of IoH has been noted earlier since 1996. After 2015 the publication activity about IoH has significantly declined. The term IoH was replaced by more popular and more comprehensive term IoT.

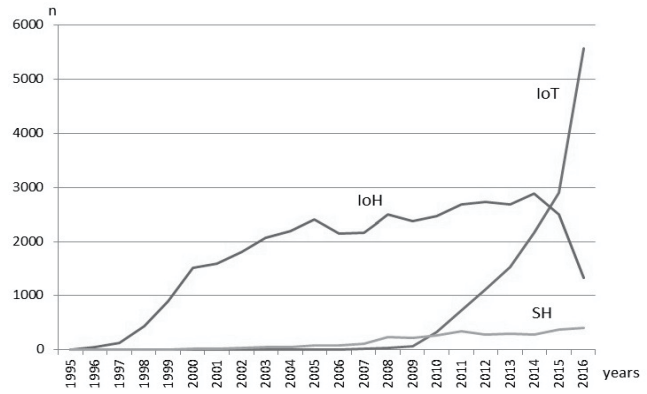

Fig. 1. Publication activity by keywords: Internet of Things (IoT), Internet of Health (IoH), Smart Health (SH). Source: Scopus database www.scopus.com, access in April-May 2017. Data Mining and analysis of data (number of keywords) were performed by Lydia Myakinkova, SRI Federal Research Centre for Projects Evaluation and Consulting Services, 2017.

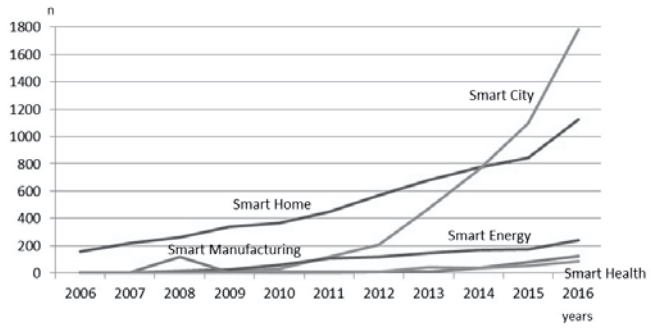

Fig. 2. Publication activity by keywords: Smart Health, Smart Home, Smart City, Smart Manufacturing, Smart Energy. Source: Scopus database www.scopus.com, access in April-May 2017. Data Mining and analysis of data (number of keywords) were performed by Lydia Myakinkova, SRI Federal Research Centre for Projects Evaluation and Consulting Services, 2017.

The citation of Smart Health has appeared in Scopus database in 1986, far earlier than 2000s. It was characterized by slow growth during two decades, and citation was steadily growing since 2008 while the new impetus was given for Health Care due to Internet and mobile technology. The data show the emergence of qualitatively new object in scientific investigations that is interdisciplinary and embraces both Health Care and Information Technology (IT). At Fig. 2 the publication activity about other "Smart" concepts is shown in comparison. Smart Health has the lowest level of citation compared with comprehensive concepts of human environment – Smart Home and Smart City. This is the sign that Health Care has shifted its focus from narrow to covering the entire ecosystem of human life: both concepts Smart Home and Smart City include medical monitoring and medical support.

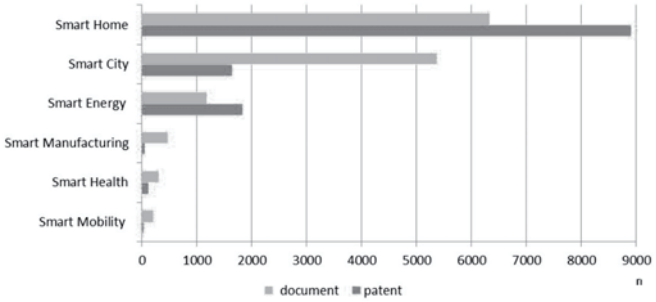

Fig. 3. Publication and patent activity by keywords: Smart Home, Smart City, Smart Energy, Smart Manufacturing, Smart Health, Smart Mobility. Source: Scopus database www.scopus.com, access in April-May 2017. Data Mining and analysis of data (number of keywords) were performed by Lydia Myakinkova, SRI Federal Research Centre for Projects Evaluation and Consulting Services, 2017.

The data presented at Fig. 3 show that there is absolute leader in patents registration – concept Smart Home, ecosystem of human life. It also points to an important trend: medical technologies adapt to diagnostics outside hospitals. New trend is not even outpatient care, it is something entirely new – medical consultations people at home using IoT, based on Big Data, mobile and online technology. For example, the report "Insights into patient preferences on telemedicine, wearables and post-discharge care" prepared by Harris Poll within the United States, include opinion of 2,025 U.S. adults and revealed some features: phone calls are the primary way to set up doctor appointments, but third patients have access to portal provided by Health Care or insurance provider; doctors share test results over the phone in 40% cases; reviewing health data happens through portal in 29% cases; third of patients keep their records in a home-based physical storage location, another third of patients use portal or website provided by Health Care or insurance provider. Most of adults (63%) said their primary care physician provides virtual care services such as phone, email, Health Care provider apps. 39% of Millennials (born in 2000s) own a wearable device for daily health control, 62% of respondents said they choose a primary care physician who uses data from patient wearable devices to manage their health outcomes [2].

II. Popular topics: IoH and Big Data

The concept of IoH applies to several IoT areas, each of them has characteristic called Smart. It means the enhancement of an item or process by technologies, Internet services, Big Data analytics, algorithms and Artificial Intelligence (AI). These areas are the following: Smart Home, Smart Manufacturing, Smart City, Smart Mobility (intelligent exchange of information, financial transactions, e-commerce, etc.), Smart Energy (intelligent grid), Smart Earth & Ocean, Smart Circular Economy (full cycle economy, ecosystem of value chains), Smart Health (or IoH) [3]. All spheres of human life affect health. While everything around becomes Smart due to IT, it is possible to control environment influence on patient health.

"Digital" is another definition of the ongoing Information transformation. This characteristic is assigned to such concepts as Digital product, Digital process, Digital business model. Product, process and business model become digital in any field including Health Care. Today variety of portable devices, gadgets, mobile phones, machines, sensors and other objects surrounding people, more and more are formed in the digital 3D space and are created using 3D printing with plastics materials as "ink" for 3D printers. All of them constitute IoH and IoT ecosystem.

For the first time in history people surround themselves with environment of medical control. This fact changes priorities from traditional Health Care to social self-organization. Information society induces digital transformation that means each area of industry has to elaborate own digital strategy. The main characteristics of digital transformation include the following: a precise personalized approach (for example, personalized medicine), predictive analytics (for example, predictive medicine), big volume, high speed, great diversity, flexibility and mobility (agile), a spatio-temporal approach, comprehensiveness. All of these are the basic characteristics of Big Data concept and the basic approaches of Big Data analytics.

III. Anatomy of Big Data and its place in Health Care

Term Big Data was proposed by American scientist Clifford Lynch in article "Big Data: How do your data grow?" (Nature, 2008). After that the term and ideology of Big Data were picked up and developed by different scientists in United States and United Kingdom. On the one hand Big Data is the big volume of data that accumulating indefinitely, and on the other hand it is the process of accumulation digital data. It is more convenient to define Big Data as a concept that integrates data accumulation and processing.

Big Data are characterized by three V: Volume (large volume of data), Velocity (speed of data accumulation), Variety (data diversity). Big Data mostly is classified as unstructured data which accumulates in formats that cannot be statistically calculated without additional processing. Unstructured Big Data can be transformed into table or graph using special IT tools for analytics, for example programming language R or Hadoop software. In general there are many special approaches and entire arsenal of software for Big Data analytics.

Big Data in essence is the reflection in information systems different society activity, taking into account the IT influence to society. In other words Big Data reflects in information systems the influence of IT to society. This definition is important for developing the approaches for Big Data analytics. The some classification of Big Data functions can be proposed, it has described in previous articles [4], [5]. Big Data is accumulated due to society vital activity, which is a dynamic system, changing during time and in space. That is why to seek out spatio-temporal patterns while analyzing Big Data, is necessary task. Big Data analytics of people activity should consider the essence of society vital activity. Society can be compared with biological system: any human is a biological system, thus one person as well as community of people is a biological system. It can be described as some Big Frame which as biological system aspire to optimality (Optimal Frame), it can undergo transformation (Frame Transformation), or stress (Frame Stress), and also it can be changed to adapt (Frame Adaptation) [4], [5]. These Frames can be shown by Big Data.

Health Care accumulates huge volume of data, with high speed and great diversity of Big Data format: texts (medical records), numbers (laboratory tests), images (Computed Tomography, Radiography), video (sonography, videofibroendoscopy), technical signals (ECG, EEG, sphygmography, rheography), etc. Health Care is the most industry which needs data warehouses (data centers), high-performance computing, Big Data analytics services, Cloud computing (Smart Cloud). All of these are appearing in large hospitals or large medical centers.

Time is the factor which plays a leading role in the context of IoT and Big Data analytics in medicine. Length of stay in hospital will be reduced to minimum. Time of diagnosis will be reduced to minimum. Response time to an epidemic will be reduced to minimum. Outpatient time will go to mode 24/7/365.

AI can operate only based on Big Data experience. Together Big Data and AI have changed entire Health Care that promises to drive down the cost of treatment while increasing effectiveness. Hospitals can be able to treat more patients a year with the same resources (Newsweek, 2017). Once became a hospital's patient, due to a new Health Care system with Big Data and AI services, any may receive care being a subscriber to service out of hospital from hospital staff. Next few years a new market of IoT technical applications will grow, that reduce demand on conventional Health Care system while giving more access to care. The combination of Big Data and AI wasn't available until this moment, it leads to disruptive change of Health Care. Chairman, president and CEO of IBM Ginni Rometty said at HIMSS17 that IBM Watson today in 30% of complicated clinical cases finds better solutions than experienced doctors. There are some other advanced projects of AI for Health Care: Apple's Siri, Google's Assistant, Microsoft's Cortana; or for Smart Home like Amazon's Echo Alexa (TechTarget, 2017). They use voice-enabled devices such as smartphones to interact with patients in mode 24/7, and can be connected to many different devices to collect Big Data from patients. This is the outpatient platform for Smart Home and Smart City in medical aspect.

Newest trend – blockchain, digital currency Bitcoin – will probably disrupt the existing monetary order. Blockchain is maintained mostly by growing transactions of electronic Health Care Big Data and by development of blockchain for patients.

HIMSS (The Health Care Information and Management Systems Society) provides some standards for Medical Information Systems (MIS), see Table I. Only 5% of hospitals in USA today fits to 7th stages of HIMSS models. Four basic models are necessarily required Big Data analytics.

One is the eight-stage (0-7) standard called Electronic Medical Record Adoption Model (EMRAM). The highest stage means: "Hospital no longer uses paper charts to deliver and manage patient care and has a mixture of discrete data, document images, and medical images within its EMR environment; data warehousing is being used to analyze patterns of clinical data to improve quality of care, patient safety, and care delivery efficiency; clinical information can be readily shared via standardized electronic transactions (i.e., clinical data repository) with all entities that are authorized to treat the patient, or a health information exchange (i.e., other non-associated hospitals, outpatient clinics, sub-acute environments, employers, payers and patients in a data sharing environment); the hospital demonstrates summary data continuity for all hospital services (e.g., inpatient, outpatient, Emergency Department, and with any owned or managed outpatient clinics)".

Also there is eight-stage (0-7) Adoption Model for Analytics Maturity (AMAM). The 6th stage means "Clinical Risk Intervention & Predictive Analytics". The highest 7th stage "Personalized Medicine & Prescriptive Analytics" appoints: "The pinnacle of applying analytics to support patient specific prescriptive care; Health Care organizations can leverage advanced data sets, such as genomic and biometrics data to support the uniquely tailored and specific prescriptive Health Care treatments of personalized medicine; organizations can deliver mass customization of care combined with prescriptive analytics".

The Continuity of Care Maturity Model (CCMM) reflects coordinated care across the continuum of care. For example, 4th stage "Care Coordination Based On Actionable Data Using A Semantic Interoperable Patient Record" includes semantic data that drives actionable Clinical Decision Support and analytics. The 5th stage "Community-Wide Patient Records Using Applied Information With Patient Engagement Focus" means: "Patient data aggregated into a single cohesive record; mobile tech engages patients". The 6th stage "Closed Loop Care Coordination Across Care Team Members" means: "Dynamic intelligent patient record tracks closed loop care delivery and multiple care pathways/protocols for each patient along with patient compliance tracking; community-wide Clinical Decision Support and population health tracking". And the highest 7th stage "Knowledge Driven Engagement For Dynamic, Multi-Vendor, Multi-Organizational Interconnected Health Care Delivery Model" appoints: "Comprehensive pop-health; integrated personalized medicine; near real-time care community based health record and patient profile".

The Outpatient Electronic Medical Record Adoption Model (O-EMRAM) describes EMR environments. The 6th stage "Advanced Clinical Decision Support; Proactive Care Management, Structured Messaging" includes connected medical devices operating in the patient care areas. The highest 7th stage means: "The ambulatory facility no longer uses paper charts".

TABLE I. HIMSS ANALYTICS MODELS WITH BIG DATA TOPICALITY
Stages 0-7 (adapted from www.himssanalytics.org)

Electronic Medical Record Adoption Model (EMRAM)	
0	All Three Ancillaries Not Installed (Laboratory, Pharmacy, and Radiology)
1	All Three Ancillaries Installed – Lab, Rad, Pharmacy
2	Clinical Data Repository, Controlled Medical Vocabulary, Clinical Decision Support/rules engine, Health Information Exchange capable
3	Clincal Documentation, Clinical Decision Support system (Error Checking)
4	Computerized Practitioner Order Entry; Clinical Decision Support (Clinical Protocols)
5	Full R-PACS (Radiology Picture Archive and Communication Systems)
6	Physician Documentation (Templates), Full Clinical Decision Support system, Closed Loop Medication Administration
7	Complete EMR, Data Analytics To Improve Care
Adoption Model for Analytics Maturity (AMAM)	
0	Fragmented Point Solutions
1	Foundation Building: Data Aggregation And Initial Data Governance
2	Core Data Warehouse Workout: Centralized Database With An Analytics Competency Center
3	Efficient, Consistent Internal And External Report Production And Agility
4	Measuring And Managing Evidence Based Care, Care Visibility, And Waste Reduction
5	Enhancing Quality Of Care, Population Health, And Understanding The Economics Of Care
6	Clinical Risk Intervention & Predictive Analytics
7	Personalized Medicine & Prescriptive Analytics
Continuity of Care Maturity Model (CCMM)	
0	Limited Or No E-Communication
1	Basic Peer-To-Peer Data Exchange
2	Patient Centered Clinical Data Using Basic System-To-System Exchange
3	Normalized Patient Record Using Structural Interoperability
4	Care Coordination Based On Actionable Data Using A Semantic Interoperable Patient Record
5	Community-Wide Patient Records Using Applied Information With Patient Engagement Focus
6	Closed Loop Care Coordination Across Care Team Members
7	Knowledge Driven Engagement For Dynamic, Multi-Vendor, Multi-Organizational Interconnected Health Care Delivery Model
Outpatient Electronic Medical Record Adoption Model (O-EMRAM)	
0	Paper Chart Based
1	Desktop Access To Clinical Information, Unstructured Data, Multiple Data Sources, Intra-Office/Informal Messaging
2	Beginning Of A Clinical Data Repository With Orders And Results, Computers May Be At Point-Of-Care, Access To Results From Outside Facilities
3	Electronic Messaging, Computers Have Replaced Paper Chart, Clinical Documentation And Clinical Decision Support
4	Computerized Practitioner Order Entry, Use Of Structured Data For Accessibility In EMR And Internal And External Sharing Of Data
5	Personal Health Record, Online Tethered Patient Portal
6	Advanced Clinical Decision Support; Proactive Care Management, Structured Messaging
7	Complete EMR: External Health Information Exchange, Data Analytics, Governance, Disaster Recovery

Today economy is shifted to Data-Driven-economy. Medicine also is shifted to Data-Driven-medicine with Big Data medical ecosystem which interacts with society and affects it. The "plantations" of collected medical Big Data should be created (i.e., growing data centers). This data becomes capital which will be one of the main sources of Health Care financing. The emerged Big Data market has been divided into several sectors: Big Data for analytics and increasing the efficiency in hospital; selling Big Data to market agents; accumulation Big Data by market agents in independent data center; analytical services for hospitals which provide access to their Big Data.

Data centers can record all possible medical and social data from generation. It is possible to analyze the development of various diseases with all clinical variations, cases, complications, outcomes, together with genetic analysis (DNA sequencing), social status, type of job, habits, behavior, nutrition, ecology. Big Data gives incredible opportunity for understanding of diseases pathogenesis in conjunction with genes expression searching for different interactions. The main value of Big Data is the ability to provide forecast, due to retrospective data analytics or in real time mode.

Three new professions should appear in hospitals: Chief Data Officer (CDO), Chief Artificial Intelligence Officer (CAIO) and Chief Robotics Officer (CRO), and many Data Stewards. CDO is responsible for Big Data strategy (the way data is used to generate new value) and Big Data governance (the way data is gathered, stored, and protected) [6]. CAIO should be able to apply AI across data. CRO will be responsible of the overall automatization of workflows based on Big Data and to integrate them smoothly into daily activities (Datafloq, 2017).

It is important to build a "bridge" between Ministry of Health, hospitals authority, inventors, developers, vendors and medical staff for better elaboration of MIS which are the tools for Big Data collection and analysis. Some measures for MIS improvement should be proposed.

• Use MIS that allow within agreed upon business processes to expand and modify the doctors primary records.

• Development of methods (technologies) for determining the indicators of current patient's status without time limits and out of the doctor's office.

• Continuous increase of computing power of regional data processing centers; increase of data processing efficiency improving tools of Big Data analytics.

• Task of developing working methods with Big Data in Health Care must be the priority.

Ministry of Health of Russian Federation has developed the Information transformation of Health Care [7]. Federal Data Center for Unified State Health Information System (EGISZ) has been financed by Ministry of Health. In 2017 the Ministry of Health will spend more than 1.179 billion rubles for EGISZ. The data center, rented by the Ministry of Health, aggregates data from The Integrated Electronic Medical Records, Electronic Registry, other different systems.

IV. Advanced users as IoT Drivers

According to McKinsey Global Institute report "Digital America: A Tale of the haves and have-mores" [8] 3D printing technology will be the leading trend in near future which will change economy. Consumers will make needed products by themselves using 3D printing technology (custom-ordered 3D products). This is the new principle "prosumer" (producer plus consumer) which has been described intuitively by Alvin Toffler in the past century as erasure of the gap between producer and consumer. This new economic principle "prosumer", so precisely foreseen by Alvin Toffler, has already changed all spheres of society life including Health Care. The increasing interest in this topic is shown at Fig. 4. First 3D printing patents appeared in 1978. The prevalence of patents over the common interest should be noticed that points out to formation of commercial market in the field of 3D printing. Today 3D printing fills the professional niche of high-tech medical care. But it will expand soon to patients self-service.

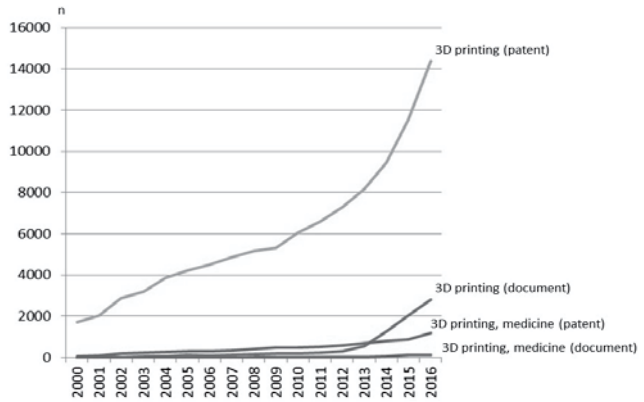

Fig. 4. Publication and patent activity by keywords 3D printing and 3D printing, medicine. Source: Scopus database www.scopus.com, access in April-May 2017. Data Mining and analysis of data (number of keywords) were performed by Lydia Myakinkova, SRI Federal Research Centre for Projects Evaluation and Consulting Services, 2017.

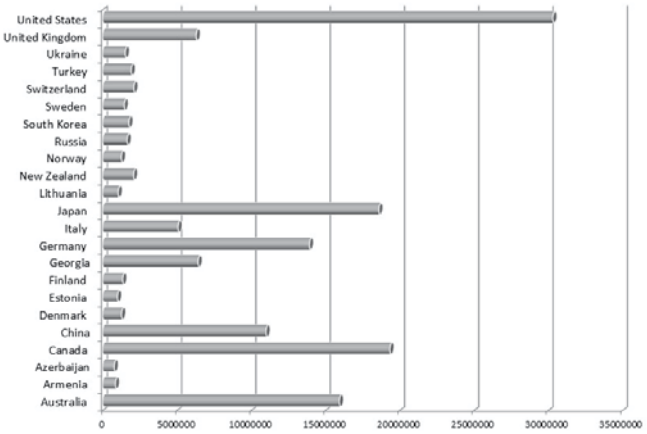

Fig. 5. Keywords 3D printing counted through API access to Google in conjunction with countries names and 2016 year of texts publication. Data Mining and analysis of data were performed by Dariya Yakovleva, Vladivostok State University of Economics and Service, 2017.

The interest in 3D printing can be assessed using Internet's keywords (Fig. 5). The global Internet environment is some

kind of global audience discussion about various processes. In this regard the identified keywords patterns reflect people interest in the issue. Some leaders are shown among countries which have interest and will develop 3D printing technology: USA, Canada, Japan, Germany, China, Australia.

At Fig. 6 the interest in robots technology is presented. Robotics is the integral part of AI technology as well as IoT that has already widely used in Health Care. Predictable leaders are USA, South Korea, Canada, Russia.

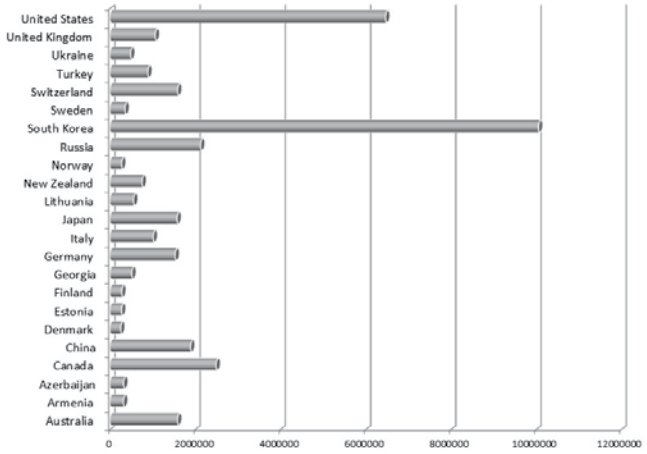

Fig. 6. Keywords Robotics counted through API access to Google in conjunction with countries names and 2016 year of texts publication. Data Mining and analysis of data were performed by Dariya Yakovleva, Vladivostok State University of Economics and Service, 2017.

To the synthetic principle "prosumer" the concept of "professional consumer" is added. Patient becomes a professional prosumer which has higher awareness in medicine than before. 3D printing medical market for patients self-service will exceed $3 billion by 2024 (TechTarget, 2017). Predominantly this market will consist of small portable wearable devices or wearables (and their components) which record different physiological parameters of patient in real life or supplement physiological functions (hearing aids, etc.). New materials which will be included into IoT ecosystem should have some special properties with sensory and communication functions (Smart Connected Devices). These materials are based on nanoelectronics, organic electronics, they give new functionality to clothes, watches, glasses, medical portable devices, etc. These are "ubiquitous devices" which tend to expand to everywhere and become multifunctional. For example, Smart wristwatch, which allows to reading texts from Internet, as well as measuring pulse, blood pressure, oxygen saturation of blood, and at the same time it can open electronic locks of house door and car, pay in supermarket and trip, pay rent and bills through contact with terminals or Internet.

There are five of the new wearable technologies that have proven to help people with disabilities: Dot, Talkkit, UNI, AXS Map, and assist-Mi (Datafloq, 2017). Dot is Braille smartwatch which helps the blind read messages, tweets, posts, and books. Dot works through bluetooth by having four sets of six braille dots on the surface of the smartwatch. Talkkit technology helps people with speech and language disorders better communicate. Wearable device translates unrecognizable pronunciation into understandable speech. It works by learning the individual's speech patterns and then creating a personal speech dictionary. UNI is wearable device for the deaf. Specialized camera technology converts sign language into words and converts speech into text to allow two-way communication. AXS Map is crowdsourced map that carries information about wheelchair-accessible ramps and restrooms. Assit-Mi is assistance application which helps people with disabilities to receive fast and easy assistance. App connects service providers and caregivers with the disabled who may be in need of immediate assistance (for example, shopping for groceries).

Hyperconnectivity of devices in IoT ecosystem is one of key features of the new reality. Cloud technology allows to record patient's medical parameters outside hospital and doctor's office. The transfer of the majority diagnostic investigation of patient outside the walls of doctor's office will appear in near future. The most developed Smart Devices (Smart Wearables) with mobile apps today are: sensor fixed on chest for patients with bronchial asthma, it records respiratory rate, cough, rales, heart rate; motion sensor fixed to back or knee, it helps to overcome pain; sensor-accelerometer for people with obesity; ECG recorder for detection of arrhythmia, stenocardia; blood pressure measurer (photoplethysmography sensor or infrared sensor in wristlet) for patients with arterial hypertension; electrochemical sensor in eye contact lenses for determining glucose in a tear fluid for patients with diabetes mellitus; sensor which records muscle cramps for patients with epilepsy; women's underwear with infrared temperature sensors for early detection of breast cancer; swallowed microsensors for diagnosis of gastrointestinal tract; signaling sensor to keep a straight back for prevent scoliosis. Devices for diseases diagnosis and prevention become more and more widespread.

V. From ePatients to Internet-Patients

Along with the term Internet of Things there are other terms Internet of Everything, Internet of People and Internet of Me [9]. These terms reflect a personalized approach based on increasing support for each user through IT (Context-as-a-Service). All processes of Health Care are moving outside the traditional framework. Hyperconnectivity is being created due to round-the-clock monitoring of health parameters by Smart Devices connected with mobile applications and experts' algorithms for assessing health. The social role of Health Care is being transformed. The revision of Health Care system, its organization's approaches, responsibility, control measures, assurance is needed. The essence of concept "patient" is changing. Today this concept is blurred and doesn't apply anymore to scope limited by the length of stay in hospitals during episode of hospitalization. Simple patient transforms into an e-patient (all records about patient have been digitized) and then into Internet-patient with monitoring of health parameters within the IoT ecosystem surrounding people. Medical data has become part of Internet that influences to Data-Driven-economy and gives a new dependence on economy.

Necessarily to mention the Data Stream Pipeline which collects data in such aggregator as Data Lake. It is the basic form of the digital strategy and definitely it will replace the current approaches of Health Care. Society self-management and self-regulation will appeared instead conventional Health Care management. The transition to Cloud computing, Big Data analytics, supercomputers, AI, 3D printing can be compared with the "phase aggregate transition" from one condition (static and slow) to another (flexible, dynamic, ubiquitous). Large hospitals in the near future will be based on three "whales": hybrid Cloud computing, supercomputer and data center. These three features in general will be the main critical points for growth of all Health Care system.

The new trends don't cause a decline in profitability of Health Care or don't become financial burden for family budget. Conversely the delay in the digital transformation of Health Care and absence of integrating into IoT will enhance the crisis during transition period. The Digital strategy is needed, it should determine the way to society self-management of Health Care system and also it should establish new services that will make inflow of financial revenues into Health Care system.

The Roadmap for Healthnet (the market of personalized Health Care services and drugs) has been developed by National Technology Initiative in Russia, which describes the innovative areas such as IoH up to 2035 [10]. Healthnet includes many tasks: elaboration of MIS, Electronic Medical Records, Clinical Decision Support based on Big Data algorithms for patient care with arterial hypertension, diabetes mellitus, bronchial asthma, ischemic heart disease, arrhythmia, heart failure. Some services for remote monitoring will be developed (blood pressure, ECG, environmental factors, etc.). And some devices with SIM cards and apps will be created – tonometer, glucometer, spirometer, ECG monitor, etc. Other advanced devices are blueprinted: implantable therapeutic / diagnostic artificial regulatory systems, nanodevices, diagnostic home modules.

There is another project of National Technology Initiative called the Roadmap for SafeNet. It also includes IoH elements and covers biometric control and user authentication systems, portable devices for monitoring of vital signs, mobile medical devices for staff of critical infrastructure facilities. SafeNet will expand to such parts of IoT as Smart City, Smart Mobility, Smart Home, Smart Grid, Smart Life, Safe Environment.

VI. IoH Transformation Vectors

The IoT ecosystem as a whole and its medical segment IoH foreground some important aspects related to gerontology, genetics, biorhythmology and gravitational biology.

1) Gerontology. Population in 21st century lives longer due to comprehensive medical control, therefore society becomes older. The proportion of elderly people over 60 years old increases, that is the budget burden. This is the current social phenomenon called Third Age which requires to enforce gerontological direction in Health Care. Considering digital transformation of the entire workforce market, older people can remain employees longer than ever. IoH will provide care and support out of hospitals and round-the-clock with gerontological specialization. Thus IoH is only way how Third Age society can reduce the burden on state budget.

2) Genetics. It refers to personalized medicine; genome sequencing will become an obligatory procedure in the foreseeable future for each person at very earliest time during life. "Genetic passport" will determine the entire life cycle of a person's medical care based on Big Data, including risk stratification, career guidance, choice of medications. Genetics is the most promising trend, together with AI it will lead to a qualitative change of human. The acceptance and common interest in genetic changes can be assessed using Internet's keywords GMO and GMO harmful. At Fig. 7 the interest in GMO (genetically modified organism) is shown in different countries. Can be noticed that in general people in the world have accepted GMO and have showed less interest in harm of GMO than just in GMO. Looking to Fig. 7 can be predicted some leaders among countries which will compete among each other at global market related to genetics: USA, Japan, China, Canada, Australia.

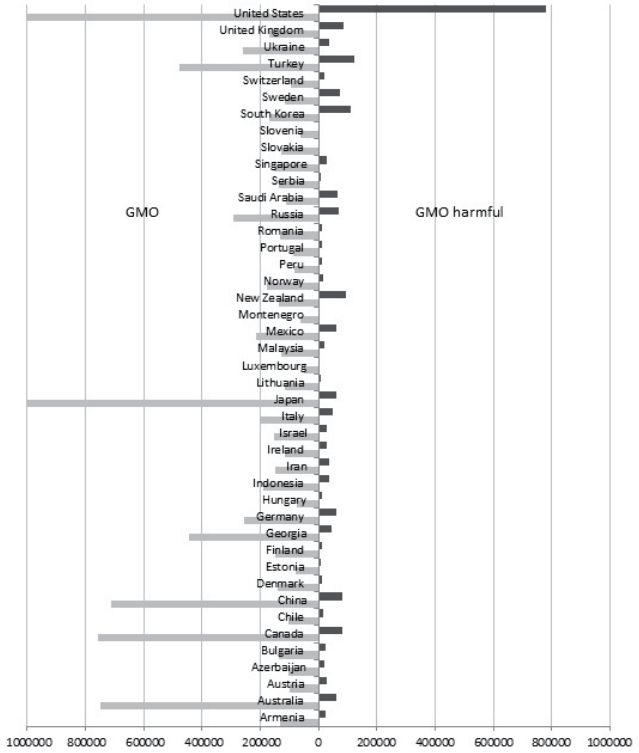

Fig. 7. Keywords GMO and GMO harmful counted through API access to Google in conjunction with countries names and 2016 year of texts publication. Data Mining and analysis of data were performed by Dariya Yakovleva, Vladivostok State University of Economics and Service, 2017.

3) Biorhythmology and gravitational medicine. These two directions of biomedical science are directly related to the era of IoH. People record their health parameters during daily life being under constant influence of gravity force and natural biorhythms. Three blocks of body regulation can be described: environmental, behavioral and homeostatic [11], [12], [13], [14]. The environment block includes annual rhythms and circadian rhythms. The behavioral block includes body

orientation under constant influence of gravity force (lying, standing, sitting), active movement (walking, running, physical loading) and passive movement (lift, transport) under influence of acceleration force; as well as sleep, eating, emotional reactions. The homeostatic block is directly related to physiological processes of body regulation. This block includes various physiological functional systems described by Russian scientist K.V. Sudakov and followers in Sechenov First Moscow State Medical University [15].

VII. Expanding Horizons: Augmented Reality

IoH changes the concept of Sociology of Medicine. Professional prosumer by itself provides measures for prevention, diagnosis and control of disease treatment due to IoH ecosystem.

The founder of the Russian Sociology of Medicine, Academician A.V. Reshetnikov emphasized the role of medical culture in whole socio-cultural system [16], [17], [18]. Medicine regulates people's behavior, establishes norms and rules, motivates or imposes restrictions. Today medicine as part of social structure becomes more and more diffuse, dispersed due to IoH, covering common space of IoT-society. Hence the medical culture acquires a new value for society. And vice versa social process or social crisis have a greater impact on medicine and medical culture than before.

Patient is the core of medicine. In the IoH ecosystem the concept of "patient" is also becomes more and more diffuse, dispersed. The framework of psychological and physiological capabilities of human is going to be blurred, beyond the studied psychological and physiological loading on a person. The Augmented Reality (AR) is the reason of growing burden on human, because it supplements the extra capabilities and extra psychological and physiological abilities. The different AR projects have already existed: Magic Leap, HoloLens, Smart Glasses, Neuralink. And also there are Smart clothes, Smart airplane windscreen, etc. They all give additional sensory data for human perception which didn't exist in nature.

Elon Musk in 2016 proposed the concept of Neural Lace that is the concept of Digital Intelligence which provides brain-computer communication through an implant (direct neural interface). Human-computer interfaces are already used in a wide range: from scientific implants to custom gestures, video-oculographic or voice interfaces. More and more people are getting involved in AR, and patient is becoming a Digital patient. AR methods are already being developed to treat patients, for example, with phantom pain after limb amputation (using electromyography, a virtual model of a lost limb, and training patient to move the virtual limb). The large-scale introduction of AR as methods of treatment and patient self-control is beyond doubt. The new cybernetic breakthrough is expected in the technology of NBIC convergence (nano-, bio-, info-, cognitive-), or GRAIN technology (genetics, robotics, AI, nanotechnology).

The ultimate goal of the cybernetic breakthrough is Transhumanism, (Humanity Plus, H +). The concept of H + implies human improving – intelligence, physical abilities, psychological characteristics, social aspects. These new extra capabilities human can acquire due to IT, electronics, devices and chips, gadgets, biotechnologies, genetic changes. The main object of transformation during new cybernetic breakthrough is a human, thus medicine will take the central place in society life and in new technological order [19]. The human transformation will inevitably be accompanied by society transformation, which implies medicine, that will take the central place and also will lead in society governance.

VIII. Context-as-a-Service and Farsighted Forecast

AR serves as a key for IoT, it is a channel for human communication with high-speed world of IoT. The control of any device, machine, object of infrastructure (in any professional sphere, including medicine) will be carried out by a person through AR within a framework of IoT. AR-operator will be able to see the working "mechanism" of any object from within. Complex streaming information will be collected and displayed on interface with Big Data analytics, forecast and recommendations. AR-operator will have decision-making support, with the possibility of making corrections or necessary actions. In general it is called Context-as-a-Service. In medicine this trend is developing as decision-making support for doctors.

Context-as-a-Service is a term which defines the conditions for required level of labor productivity and quality. It also applies to managing patient's health by itself within IoH (control, prevention, diagnosis, treatment). From the medical point of view the concept of Context-as-a-Service inverts Health Care figuratively upside down. Health Care will start from every person who will not be a patient in a hospital, but a subject of IoT-society. His or her health will be controlled at every step due to Smart Home, Smart City and other Smart environment. That is why the authors dare to assert that the discipline Sociology of Medicine is becoming foreground among such relevant to IT progress disciplines as Personalized Medicine and Medical Cybernetics and Informatics. Both are just parts of general, and general is the comprehensive surroundings of human and society by IoT.

Sociological understanding of people's role in the formation of the new high IT dependence reality allows to determine the main vectors of farsighted forecast. Today with high confidence can be confirmed that the current evolution of IT is the milestone in society development which leads to technological (information) immortality of humankind. Expected phenomena of the future society are very dynamic, with separated information flows (including medical ones) and with increasing society dependence on technology. Also the medicalization of society with high political influence of medical culture can be predicted.

With the penetration of IT into all spheres of human life the problems associated with information security are risen. Cases of so-called Identity theft are spreading more and more and is becoming an increasingly common problem. There were 44 huge leaks of personal data in 2016 worldwide. At least 10 million personal, mostly financial data were stolen (Herald of Digital Transformation, 2017). Any fraud (theft of health data, hackers penetration into the medical network and life support

systems) is fraught with unpredicted consequences. The risk associated with IoT and with spread of network connections is increased. Users' devices are the most vulnerable and less secure. The problem is worsened by the large number and variety of these devices [20]. The international laws for data protection are needed to counter cybercrime.

People cannot provide all IoT services by themselves, that is why AI bots has appeared. A bot is an AI application that offers a human-like interaction. Health Care bots can interact with patients via telephone or on a website chat window. Bots can be used in different situation: as medication reminder or reminder to check glucose level, for scheduling doctor's appointments, to receive help after request, for patient education. Bots help to reduce the overall administrative costs for hospitals. There are also some scientific experiments in that bots began conversing each other in a mathematical language that only they could understand (Facebook Artificial Intelligence Research). The goal to training AI bots to negotiate with each other has been set. But today AI has already shown that it can perform cognitive tasks faster than a human.

AI has already been used as Context-as-a-Service, for example IBM's Smart Cloud. AI applies in oncology to help detect abnormalities in X-rays and MRIs; in genomics to perform processing; in precision medicine to provide evidence-based treatment recommendations; to process structured and unstructured patient data in hospitals. AI (bot) can interact with patients and collect data about symptoms (anamnesis) through mobile apps. AI / Machine learning can be used in a wide range of important Health Care scenarios, including fetal monitoring, early detection of sepsis, identifying risky combinations of drugs, and predicting hospital readmissions [21].

The creation of numerous downloadable apps specific to hospitals, doctors or patients is expected (Datafloq, 2017), [22], [23]. AI matured work in hospitals will appear within next 5 years (Healthcare IT New & HIMSS Analytics, 2017).

IX. Risks, Society Transformation and Economic Growth Resource

The society is already undergoing several transforming processes: 1) chaos, loss of landmarks; 2) gamification, virtual life; 3) acceleration, rising speed of information exchange. All three mentioned transforming processes require an assessment of risks and threats to society. The most dangerous is changing situation from People-to-IT (people control IT) to IT-to-People (when AI would control society). Well-known scientists such as Stephen Hawking, Bill Gates and Elon Musk have said that AI could become so powerful and self-aware that it may put its own interests before those of humans (TechTarget, 2017). Today this scenario seems to be a science fiction, but it is important to prevent excessive directive penetration of IT into the society life. This can bring some risks of discrimination, loss of human rights and freedom, loss of humanistic values to complete destruction of the civilization.

IoT technologies such as AR facilitate human expression of will even by one click that is critically important milestone for security and ethics. There haven't had time in history yet while human expression of will could quickly disrupt the society security or society ethics by one click.

In summary, the modern technological evolution can be described as subsequent stages: distribution of IT – automation – Digital transformation and IoT – Big Data analytics – AI solutions – people connection to AR – Context-as-A-Service – NBIC- and GRAIN-technologies – Humanity Plus. In order to confront negative scenarios, necessary develop social / socio-medical ethics as a control and containment mechanism. Further technological evolution goes, more it involves medicine, bioethics, social and medical ethics, the principle "do no harm", rights of patients and the presumption of innocence in cases of risk stratification and prediction of deviant behavior based on Big Data.

From the very beginning IT contributed to transformation of society. Russian scientist S.P. Kapitsa argued that since the 19th century when telegraph has appeared, the development of communication and information exchange bolstered the human population growth as never ever before [24]. This impetus for growth S.P. Kapitsa explained by information and knowledge transfer from generation to generation and within population that helps to survive and improves Health Care.

The current IT evolution brings not only knowledge and opportunities, but also risks which haven't yet understood. First of all, these risks are unemployment, socio-economic inequality and the disruptive power of new technologies (disruptive technology). Experts of the World Economic Forum proposed the social protection of population during the Fourth Industrial Revolution [25], [26]. But also necessary comprehend the role of medicine in social population protection during technological revolution.

The development of medicine as the foundation of society life is observed. Social and medical ethics should create a balance and prevent risks of IoT expanding into political system. A lot of time and a lot of people are freed from the new economy based on Information transformation, but the new Cloud market with Cloud employment of population hasn't yet formed completely. IoT and Big Data analytics accelerate all processes in the economy, medical assistance becomes faster and better, the quality of people lives is increasing, labor force is being replaced by robotic force. Thus a lot of free extra time and people are appeared – unemployment and also Third Age of elderly people who live longer due to IoH and IoT with rising chances of delay disability.

This resource of extra time and extra people is arising mainly through the convergence of medicine with IT, and this should be used for economic growth. But situation can be described through another way as a vicious circle with increasing unemployment and budget burden. The scenario of vicious circle means to get rid of budget burden including the introduction of a special tax for unemployed people and limitation of their unpaid Health Care.

The country prosperity depends on social and medical ethics. Creation of a new big Cloud market will guarantee economic growth, it can fill the space of extra time and people with new jobs and without new tax and Health Care limitation.

If the way through vicious circle will be chosen, the economy will gradually fall with shrinking of labor reserve needed for a new Cloud market.

X. Conclusion. Recommended Measures for IoH Development

Thus during current changing of the technological order, Health Care should be considered as top priority for economy. Health Care is under the influence of Information transformation and also its transformation has an impact on society. Ministry of Health of the Russian Federation actively provides development of Health Care Information transformation. Some important measures should be recommended.

A. Hybrid Cloud computing, SaaS model

Health Care needs to establish Hybrid Cloud computing (combining public open part and password-protected part) with virtual network and workplaces for medical staff. Cloud computing, data centers, supercomputers and Big Data analytics are the new basic components of an infrastructure of hospitals. Cloud services can be used as SaaS model (Software as a Service).

B. Cloud platform Context-as-a-Service

Multifunctional Cloud platform for Russian Health Care should be created (similar to Amazon, Microsoft, VMware, IBM) which will includes data collection and analytics, AI services, Context-as-a-Service services, decision-making support.

C. Russian domestic market of Big Data analytics

Establishment of Big Data domestic market is the decisive issue. It should have open foundation with free access to Big Data analytics for scientific research community. Promotion of Big Data analytics will aid to reinforce the commercial Big Data market for Health Care earnings.

D. External outpatient contour: Life Coaching services from hospitals

Orientation of Health Care mostly to an external outpatient contour will be relevant to needed Information transformation. The foreseeable approach is Individually-oriented IT-routes of medical support within Smart Home and Smart City that called Personal Life Coaching services for patients with chronic diseases. They can receive feedback using mobile apps on a number of data elements captured on their wearable devices.

E. Telemedicine: Health Care virtual assistant

Physicians and nurses should be encouraged to move to telemedicine services. The predominance of telemedicine workplaces than numbers of doctor's offices and patients' places in hospitals is the clear feature of future.

References

[1] A. Toffler, *The Third Wave*. Transl., Russia, Moscow: AST Publishing, 2004.

[2] H. Poll, *Insights into patient preferences on telemedicine, wearables and post-discharge care,* Connected Patient Report. Salesforce Research, 2016.

[3] O. Vermesan and P. Friess, *Digitising the Industry. Internet of Things Connecting the Physical, Digital and Virtual Worlds*. River Publishers, 2016, 338 p.

[4] G. Smorodin and O. Kolesnichenko, "Big Data as the Big Game Changer", *in Proc. 9th International Conference on Application of Information and Communication Technologies*. IEEE, Russia, Rostov-on-Don, 2015, pp. 40-43.

[5] O. Kolesnichenko, G. Smorodin, I. Ilyin, O. Zhurenkov, L. Mazelis, D. Yakovleva and V. Dashonok, "Big Data Analytics. New opportunity to understand the global processes", *in Proc. IV International Scientific Congress Globalistics-2015, dedicated to the 70th anniversary of the United Nations,* Moscow, Russia, 2015.

[6] J. Steele, *Understanding the Chief Data Officer*. USA: O'Reilly Media, 2017, 37 p.

[7] V.I. Skvortsova, Speech by the Minister of Health of the Russian Federation at the Meeting of Government Council on Strategic Development and Priority Projects of Russian Federation. Moscow, Russia, March 21, 2017.

[8] J. Manyika, S. Ramaswamy, S. Khanna, H. Sarrazin, G. Pinkus, G. Sethupathy and A. Yaffe, *Digital America: A tale of the haves and have-mores,* McKinsey Global Institute Report. New York, 2015.

[9] B. Schmarzo, "Big Data is About Getting Small", *EMC Blog In Focus*. June 20, 2016.

[10] HealthNet Roadmap, National Technology Initiative of Russian Federation, ed. by A.E. Repik and I.N. Kagramanjan. 2017, 222 p.

[11] S.I. Stepanova, *Actual problems of Space Biorhythmology*, in Problems of Space Biology, vol. 23. Russia, Moscow: Science, 1977, 311 p.

[12] J. Aschoff, *Biological Rhythms*, vol. 1. Transl., Russia, Moscow: The World, 1984, 414 p.

[13] G.S. Belkaniya, *Functional antigravity system*, in Problems of Space Biology, vol. 45. Russia, Moscow: Science, 1983, 288 p.

[14] N.A. Rassolov and O.Yu. Kolesnichenko, *Chronobiological aspects of arterial hypertension in the practice of Aviation Medical Examination*. Russia, Moscow: RMAPO, 2000, 178 p.

[15] *Functional systems of the body*, ed. by K.V. Sudakov. Russia, Moscow: Medicine, 1987, 432 p.

[16] A.V. Reshetnikov and S.A. Efimenko, *Sociology of the patient*. Russia, Moscow: Zdorov'e i obshhestvo, 2008, 304 p.

[17] A.V. Reshetnikov, "Sociological Theory of Society and Personality", *Sociology of Medicine Journal*, vol. 4, N 1, 2004, pp. 3-15.

[18] A.V. Reshetnikov, N.V. Prisyazhnaya, S.V. Pavlov, M.A. Petrov and S.K. Isenov, "Medical and sociological investigation of health problems: a zone of social responsibility", *Sociology of Medicine Journal*, vol. 15, N 2, 2016, pp. 68-79.

[19] L.E. Grinin and A.L. Grinin, "Cybernetic Revolution and the Sixth technological order", *in Kondratiev's waves. Heritage and Modernity*. Volgograd: Uchitel, 2015, pp. 83-106.

[20] N. Kaspersky, "Internet of Things is the dangerous phenomenon", *Tsargrad*, 2017.

[21] M. Barlow, *AI and Medicine*. USA: O'Reilly Media Inc., 2016.

[22] A. Reyss and S. Balandin, "Healthcare, medical support and consultancy applications and services for mobile devices", *in Proc. SIBIRCON Conf.,* IEEE, 2010, pp. 300-305.

[23] D.G. Korzun, A.V. Borodin, A.V. Paramonov, A.M. Vasilyev and S.I. Balandin, "Smart spaces enabled mobile healthcare services in Internet of Things environments", *International Journal of Embedded and Real-Time Communication Systems*, vol. 6, N 1, 2015, pp. 1-27.

[24] S.P. Kapitsa, "Essay on the Theory of human population growth. Demographic revolution and information society", *in Special Edition of public lectures "Russia in the Global context",* Moscow, Russia, 2008, 65 p.

[25] K. Schwab, "The Age of Adaptation", *Project Syndicate*. Feb 19, 2015.

[26] *The Global Risks Report 2017*, 12th ed. Geneva: World Economic Forum, 2017.