




# The Application of Modern High Technologies in Medicine: Biotechnology, Genetic Engineering, Nano- and Supramolecular Chemistry and Intelligent Systems

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**Abstract:** Medicine today has made a great leap forward, introducing new technologies, creating drugs that at first glance seem fantastic. Such complex concepts as biotechnology, genetic engineering, nano- and supramolecular chemistry are actively studied and found practical application. Speaking of intelligent systems in the Medtech market, it should be noted that they are based on artificial intelligence, which is used in various fields: surgery, pharmaceuticals, genetic analysis, personalization of information, Health Management Devices, digital learning, etc. The Russian market is actively introducing innovations, which proves the growth of the use of technologies in 2025 compared to 2024, which carries not only advantages for market participants, but also risks, quite complex, unpredictable and partly unregulated by legislation.

## 1 INTRODUCTION

It is possible to say with firm confidence that there are practically no areas of life into which digitalization would not penetrate, which is more expressed in the transformation of data into digital, remote customer service (submitting applications online, remote appointment), creating an ecosystem in the organization (cloud platforms, analytical tools, mobile applications). The spread and role of modern technology is growing exponentially. From year to year, the task is to modernize what, at first glance, has already reached the peak that everyone was waiting for. This approach allows you to preserve and increase the sovereignty of the country. Technologies both optimize routine work and participate in the creation of something completely new and untested.


Having studied digital technologies in medicine, it is difficult to quickly navigate the concepts inherent in this area and how they are related to digitalization.


We are talking about biotechnology, genetic engineering, nano- and supramolecular chemistry. Many questions arise. What do these concepts hide in themselves at all? Why is the development of these areas, implementation, study, creation of a completely new one very valuable both for an individual country and for the world as a whole? For what reason does digitalization in medicine make such a fuss on a human scale? What are the consequences of improving the Medtech rank, the impact of artificial intelligence on it? All this must be dealt with by defining goals and objectives.


The fundamental goal of the study is a detailed study of the concepts: biotechnology, genetic engineering, nano- and supramolecular chemistry, their areas of application, the study of international experience and the determination of possible risks of using technologies.

To achieve the goal, the following tasks are set:

1. determining the trend for digitalization.

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2. Consideration of concepts: biotechnology, genetic engineering, nano- and supramolecular chemistry.
3. Classification of areas of application of digitalization expressed by artificial intelligence in medicine, with the definition of the essence of each.
4. Study of the growth of digitalization in Russia, determining the progressive directions of modernization.
5. Analysis of the legislative framework of the Russian Federation for the regulation of the medical services market in terms of digital technologies.
6. Research on the practical experience of applying new technologies at the global level.
7. Proposal for a classification of probable risks from the introduction of technologies into medicine, in particular artificial intelligence.

Caring for health, regulating the quality of life, longevity - questions are quite trembling today. The emergence of new diseases requires completely progressive treatment methods, where it is impossible to do without technological machines that can quickly, more accurately determine the cause of the disease and provide a treatment plan. But do not lose vigilance and blindly believe artificial friends who also have the right to make a mistake, where the price is a person's health or life. In this regard, the legislative framework of each country or the general global regulation of the use and use of technologies in medicine should be clearly prescribed and monitored.

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the determination of possible risks of using technologies.

## 2 MATERIALS AND METHODS

To achieve the goal and achieve the set tasks, the following methods were used:

1. Literature review. An analysis of the current literature was carried out. It addresses aspects such as digital health, its development and the introduction of medical services to the market. Some concepts characterizing this industry are explained. Scientific articles were studied. Their publication is posted in international sources, as well as on Internet resources.

2. Analytical comparison. Based on the identified characteristics, the concepts of genetic and genomic engineering were compared. Each concept has its own characteristics. To better understand the difference, the goals and areas of application of each concept are defined.

3. Classification. Depending on the scope of AI in medicine, areas and their characteristics were highlighted. In addition, the types of risks inherent in the Medtech market have been identified, classified and characterized.

4. Case analysis. For a deeper understanding of the presence of negative consequences of the use of modern technologies, specific examples are given. Studies have proven that the use of AI by endoscopists has reduced the percentage of detection and removal of growths if this technology is not used. Similarly, the situation was analyzed, the essence of which is the deliberate use of an erroneous AI algorithm (90% error rate) by the company when denying elderly patients the provision of important medical services, while doctors considered treatment a necessary measure.

These methods allowed to solve the set goals and objectives of the study.

## 3 RESULTS AND DISCUSSIONS

Modern technologies are being successfully introduced into the field of medicine, solving seemingly impossible problems. Digital Health - using digital technologies to improve the efficiency of health systems, improve the quality of medical services and patient data management, which includes electronic health records (EHR/EMR), software (SaMD), telemedicine - remote medical

counseling, mobile health (mHealth), artificial intelligence for image analysis and decision assistance. Unknown concepts like biotechnology, genetic engineering, nano- and supramolecular chemistry are becoming more transparent. And yet it is necessary to understand these concepts in more detail:

1) Biotechnology - technologies that combine technical and biological methods for the creation and improvement of drugs, diagnostics and treatment of diseases at the cell and tissue level. For example: antibodies, vaccines, antibiotics.

2) Genetic engineering - is a field of biotechnology and is engaged in the creation of artificial genetic forms with various properties, changes, transfers a certain gene site to obtain the desired result. Simply put, genetic engineering is a powerful tool for changing hereditary facts. But do not confuse genetic and genomic engineering. The concepts seem close, but actually relate to different areas of genetic engineering. Genomic engineering includes a set of methods and technologies for isolating genes from the body, the purpose of which is to edit the genome, while genetic engineering aims to change the genetic information of the body.

3) Nanochemistry and supramolecular chemistry. Nanochemistry is the science of nanoscale particles, up to molecules and single atoms, and supramolecular chemistry studies complex structures created from molecules, in other words, it is synthetic chemistry for the production of new elements, compounds (Kurashov, 2018).

4) Intelligent systems - systems based on artificial intelligence (AI), analyzing medical data, in order to provide recommendations when making decisions in diagnosis, treatment and informing patients about the necessary issues.

Having understood the concepts, it is easy to guess that each direction of medicine is being pointwise developed and modernized, reaching new heights. Having identified the specifics of each, let's dwell on intelligent systems and consider in a little more detail.

Intelligent systems as mentioned earlier are based on AI, which is applied in various directions.

Table 1: AI Applications in Medicine.

Area of application	Essence
Surgery	Preoperative diagnosis, patient rehabilitation assistance, 3D patient anatomy modeling

Pharmaceutics	Reducing the development and testing time of the drug, as well as improving the quality of the created drug
Genetic analysis	Analysis of genetic data to detect and prevent genetic diseases
Personalization of information	Analysis of the history of diseases, taking drugs helps to draw up personalized recommendations for visiting a particular specialist and on ways to treat diseases
Health management devices	Internet things and wearable medical devices track the general characteristics of a person's health, identifying weaknesses in the functioning of the body, giving signals about the need for close attention to certain indicators
Digital learning	Virtual reality technologies simulate situations in order to train future doctors without risking the patient

In addition to the listed areas of application of artificial intelligence, due attention should be paid to the development of telemedicine, which is expressed in remote consultation of patients, which makes the service more accessible, and this is important both for sparsely populated areas of the country and for megacities, whose residents are not ready to spend time on full-time visits to a specialist.

The latest developments are not only described in detail, but are also actively tested and applied. The Russian market of medical services, which grew by 18% in 2024 according to the analytical agency Smart Ranking, impresses both analysts and everyone interested (Fig. 1) (Nagumanova, Lazareva, 2024).

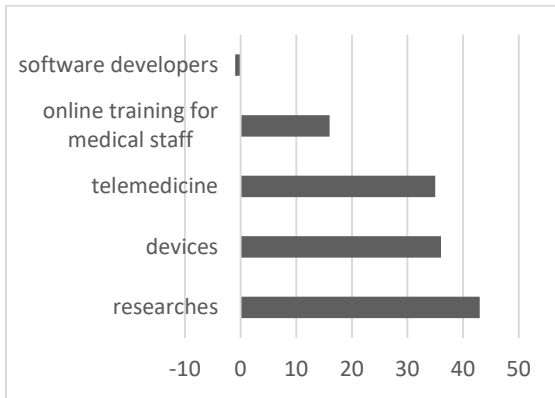


Figure 1: Changes in the improvement of areas of activity in medicine, %.

The largest growth is observed in the research segment (43%), which is justified by the modernization of the technical base, the popularization of health tracking. The spheres of devices and telemedicine are also progressing (36% and 35%). The development of devices is more expressed by the creation of prostheses, which is relevant in connection with the departure of foreign developments, and within the framework of national projects, equipment is being replaced in clinics. The improvement of AI is bearing fruit, thanks to which the integration of mobile devices with medical equipment is our reality. Controlling diabetes mellitus and blood pressure, synchronizing data from bracelets and smartwatches is not someone's imagination. Speaking about telemedicine, it is worth noting that the starting point for increasing demand was the period of the COVID-19 pandemic, when offline visits to a specialist were rather difficult. Today, this method of medical counseling is popular with many, as it helps to save time and nerves, does not limit the territorial location of doctors, while clinics and private specialists have an additional opportunity to earn money. Prominent representatives of the Russian telemedicine market are SberZdorovye, YandexZdorovye and the national platform of the Ministry of Health. Despite the restriction introduced in February 2025 on online training of medical workers, there is an increase in this format, thanks to which knowledge acquisition becomes more accessible, profitable and, accordingly, desirable for students. The area that has negative growth is software development, and the reason for this is a lack of qualified personnel, the presence of fragmentation in the software of clinics,

which creates problems in the exchange of data, and also distrust of technology on the part of medical workers.

Talking about a technological breakthrough in the field of medicine, it is impossible not to touch upon legislative aspects. In Russia, Federal Law No. 152 "On Personal Data" is in force, which establishes the basic rules for storing and processing personal data: the duties of medical institutions, doctors in particular; patient rights; data transfer to third parties, etc. (Chikhacheva, Miruk, Lomonosova, 2024). Federal Law No. 323-FZ of November 21, 2011 "On the Basics of Public Health Protection in the Russian Federation" regulates the use of electronic medical documents and digital processes. There are also orders from the Ministry of Health regulating the rules for maintaining a unified state information system in the field of health (USHIS) and the procedure for conducting telemedicine consultations.

The international experience of using technologies in the medical services market, in part, attracts attention and stimulates progress, teaching lessons for Russia. Examples of some of these are:

- USA. Widespread implementation of EHR systems, strict HIPAA data protection standards, regulation of medical software through the FDA;
- European Union. Standardization of HL7 FHIR data sharing, uniform GDPR rules, new AI Act for medicine as a high-risk area;
- China. Active development of telemedicine and AI diagnostics, the state program "Healthy China 2030" with large-scale funding;

The foreign technologies used must be carefully studied and distributed to the Russian market, otherwise called "Medtech." FHIR international interoperability standards should be implemented, telemedicine should be scaled according to the Chinese model, and European data protection practices should be adapted.

Any development, albeit at first glance, carries good intentions, at the same time presents not few problems. Studies published on August 12, 2025 in *The Lancet Gastroenterology & Hepatology*, conducted from September 2021 to March 2022 at four medical centers in Poland, showed that each action has two sides of the coin. Artificial intelligence came to the rescue to identify and remove growths, which is necessary for the prevention of bowel cancer. Specialists overly trusted new technologies, which led to a loss of motivation and vigilance in work. The frequency of detection of precancerous growths by doctors with their own hands decreased

from 28.4% to 22.4% after the use of AI. Nevertheless, the study was conducted with experienced employees, without taking into account additional factors, and under other conditions, the results could be different, but the data obtained are a signal of the need for reasonable use of modern technologies.

Another situation on the application of AI in the medical services market broke out in the United States. We are talking about the largest medical insurance company "UnitedHealth," against which a lawsuit was filed on November 14, 2023, the essence of which was the deliberate use of an erroneous AI algorithm (90% error rate) when denying elderly patients the provision of important medical services, while doctors considered treatment a necessary measure. The heirs of the 2 deceased, who filed a lawsuit, also claim that the company took advantage of the vulnerability and ignorance of elderly patients and was convinced that an incredibly small percentage would appeal the company's decision, and the majority would prefer to continue treatment on their own, paying out of pocket. And such cases are not isolated and affect various areas, for example, in jurisprudence in California, the fact of the use of generated quotes in the appeal by lawyer Amir Mostafavi was recorded. Of the references he cited to existing litigation, 90% turned out to be "hallucinations," non-existent sources. After the sensational case, the Judicial Council of California ordered to prohibit the use of AI in jurisprudence or limit, developing tough measures for its application.

As mentioned earlier, any action, technology generates negative consequences. Taking into account the analysis of the use of modern technologies in the Medtech market, we can propose a classification of risks.

Table 2: Medtech Market Risk Classification.

Concept	Essence
Patient bias	- Ongoing studies have shown that AI perceives patients differently based on skin color. Some systems perform worse with dark-skinned people, which can lead to misdiagnosis/treatment; - The algorithm is trained on historical data, which can result in an inaccurate answer if, for example, the data is taken mainly from European countries

Unreasonableness in decision-making	Quite often, algorithms are not able to explain the course of their actions, why exactly that, and not the opposite solution is correct. This is critical in medicine, in particular, when it is necessary to restore the causal relationship between the appearance of the disease, the treatment process, etc.
High dependence on data quality and quantity	Incomplete or incorrect content of data in the medical record can lead to an erroneous diagnosis, treatment, the consequences of which are scary to imagine
Error liability uncertainty	There is no legislative framework regarding the definition of responsibility that is imposed after the assumption of an artificial intelligence error. There is no clear classification of who should be responsible for the wrong result - developers, clinics or doctors
Lack of a clear, universal legislative framework	There is not only a legislative framework governing the use of intelligent systems in medicine at the global level, but also no exact legislation has been developed on the use of AI in the local sense, at the level of each country, which indicates a fragmentation in understanding the correctness and necessity of using technologies
Data vulnerability	Strong encryption must be implemented and data access regulated, as patient health information is a valuable resource for cyber fraudsters
No face-to-face patient-physician interaction	Remote counseling with a chatbot causes distrust of the response received, and personal contact with a person helps to relieve psychological tension and receive emotional support

Keeping up with the times, it is impossible not to face the accompanying completely new risks, the impact of which must be unconditionally reduced, identifying and identifying negative factors in the early stages. Competent regulation in accordance with the law is an important aspect that should not be missed by any country in the world. Legislators of the Russian Federation are taking the first steps. This is evidenced by the discussion about the prohibition of

AI with a threatening/critical level of risk, it is also planned to determine who should be responsible for the harm caused to a person. Speaking about the facts in the field of bills, the Ministry of Health approved the Code of Ethics for the use of AI in the field of health care, which is aimed at resolving issues related to the introduction and development of technologies in medical services and products.

At the moment, no country has a clear legislative framework on the use, application of AI and risk assessment related to health technologies, which is a significant problem in the digitalization of medicine.

## 4 CONCLUSIONS

The study showed that the widespread use of intelligent systems in health care, as well as in other areas of human activity, will increase. At the same time, there is a growing understanding of increasing responsibility for their application, which can be realized by developing the legislative framework in this area, as well as increasing professional skepticism in assessing the results of the use of systems. Thus, synergy is important, where intelligent systems will act as a tool that allows a person to quickly and accurately make decisions in one of the most important areas - preserving the health of mankind.

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