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Artificial Intelligence in the Healthcare System of the Arctic Regions of the Russian Federation

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Abstract. Currently, in the Russian Federation, much attention is paid to the introduction of artificial intelligence technologies into the healthcare system in order to improve the quality of medical care provided. The AI methods support the medical decision-making; it becomes possible to obtain a second opinion for a doctor when determining a diagnosis, which leads to a reduced risk of determining erroneous diagnoses (including missed pathologies). The development of high-tech medical care is a particularly relevant issue for medical institutions in the Arctic regions, which are geographically distributed and remote territories with hard natural and climatic conditions. The solution of this issue is designed to ensure natural sustainable population growth in these regions and increase the life expectancy of the population of the Russian Arctic, including the indigenous peoples of the North. The article considers the positive experience of cooperation between Russian research centers, medical companies and higher educational institutions in the development and implementation of medical software products based on technologies and methods of artificial intelligence on the example of such Arctic territories of Russia as the Yamalo-Nenets Autonomous Okrug, the Republic of Sakha (Yakutia), the Murmansk Oblast, the Republic of Karelia and the Arkhangelsk Oblast.

Keywords: *Arctic region, artificial intelligence, healthcare system, decision support system, neural network, machine learning algorithm, telemedicine*

Introduction

In 2019, the Russian Federation approved the “National strategy for the development of artificial intelligence for the period until 2030”. One of its priority areas was the use of artificial intelligence technologies in the social sphere, including for improving the quality of healthcare services [1]. The expected result of using software solutions based on artificial intelligence technolo-

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[1] Ukaz Prezidenta RF ot 10 oktyabrya 2019 g. № 490 «O razvitii iskusstvennogo intellekta v Rossiyskoy Federatsii» [Decree of the President of the Russian Federation of October 10, 2019 No. 490 “On the development of artificial intelli-

gies and methods in Russian healthcare was to improve the quality of medical services provided and, as a result, to raise the standard of living of the population.

Currently, there is a growing interest in AI solutions related to the digital transformation of healthcare both in the field of diagnosing and prognosticating diseases (including monitoring and assessing the condition of patients in real time), and supporting clinical trials and creating robotic autonomous devices [1; 2].

AI-based diagnostics enables early detection of disease, which generally contributes to increasing the predicted life expectancy of the population. The opportunity to obtain additional opinions/consultations from colleagues from the professional community reduces the risks of medical errors [3].

Medical software solutions based on AI algorithms, helping doctors at all stages of decision-making [4], are able to assess the patient's condition, save time spent on making notes when examining patients, and reduce the risks of untimely identified pathologies or erroneous diagnoses. During difficult epidemiological situations, these technologies are designed not only to significantly reduce the workload of doctors, to facilitate the work of medical staff, but also to help them save the lives of patients.

In the Arctic zone of the Russian Federation, the problem of insufficiently high quality of medical care has long been an urgent one, due to the shortage of both medical facilities and medical personnel (especially in remote, hard-to-reach regions, places of residence of indigenous and small peoples). Modern remote methods based on artificial intelligence technologies and related to prevention, diagnosis and treatment [5; 6] are intended to become a solution to this problem.

Telemedicine technologies in the regions

Telemedicine technologies are being actively introduced into the healthcare system of the Russian Federation. Today, this is not only an opportunity for patients from the regions to communicate remotely via video with a doctor of the relevant specialization.

The most common type of telemedicine in the regions is "doctor-to-doctor" consultations. This method of interaction is not necessarily based on video communication. Medical needs can be resolved by exchanging research results/medical reports, getting a second opinion on ultrasound, MRT and other studies from colleagues from other medical institutions. It should be noted that the "second reading", when the study of, for example, X-rays, is independently conducted by two doctors at the same time, improves the quality of examinations. This format of communication in the professional community is especially important for regional doctors when they are faced with difficult diagnosis/treatment or the lack of specialized doctors in regional clinics.

Telemedicine technologies allow regional doctors to send requests for planned or emergency hospitalization of patients to higher-level medical institutions and determine the possibility

gence in the Russian Federation"]. URL: https://www.garant.ru/products/ipo/prime/doc/72738946/ (accessed 30 January 2023).

of treatment on-site or at another medical center. If a patient is referred to another medical institution, the service notifies the receiving organization. At the same time, the appointment service allows the patient to choose the date and time of the visit independently. In case of hospitalization of a patient (if necessary), these technologies can solve the issues of interaction with air ambulances for geographically distributed regions.

Today, telemedicine allows holding consiliums of doctors from different medical organizations, when opinions from specialists of different fields are simultaneously required. At the same time, the system allows to solve many organizational issues, from the possibility of using digital signatures to the preparation of relevant medical reports.

Functioning telemedicine platforms make it possible to automate the work of ambulance specialists. For example, ambulance staff can transmit information that a patient in a serious condition will be hospitalized in the relevant hospital, which will undoubtedly allow this medical institution to prepare in advance for receiving the patient and provide him with the necessary assistance in a timely manner. If ambulance staff determines that hospitalization of the patient is not required, but a doctor's home call is necessary, the service also provides this option, and information about further medical care can be obtained.

An equally common type of telemedicine is the "doctor–patient" type of consultations, conducted on the results of an initial examination. In this case, both a consulting physician and a patient himself can initiate a consultation. Telemedicine platform services help a consulting physician collect the necessary medical information about a patient. Thus, after authorization through the Unified Identification and Authentication System, a patient can fill in a questionnaire (once or repeatedly) with his/her permanent (heredity, height, weight) or dynamic indicators (pulse rate, blood pressure, other results of his/her own observations) on the regional portal on the doctor's recommendation. The obtained data will allow a consulting physician to objectively assess the patient's condition and prescribe / correct the ongoing treatment.

Thus, telemedicine technologies can become the basis for medical decision-making. The range of directions is large; the priority of implementing certain capabilities of the telemedicine platform can be independently determined by regional medical institutions [2].

AI technologies in the Arctic healthcare system

Artificial intelligence, actively developing in the healthcare system, has significant results both in the field of online diagnosis of diseases based on medical images, application of speech recognition systems, and in many other areas of medical data processing and analysis [7; 8]. Let us consider some examples of effective interaction between Russian medical companies, research centers, development institutes and higher educational institutions in the development of medical

[2] Evercare. Digital medicine in Russia. Telemedicine in the regions: multilateral dialogue. URL: https://evercare.ru/ (accessed 30 January 2023).

software products based on AI technologies and used in medical institutions in the Arctic regions of Russia.

Voice2Med software for voice filling in medical documentation

The Russian company (group of companies) "Speech Technology Centre" presented the Voice2Med program, developed on the basis of artificial intelligence for medical speech recognition. The software product allows filling out medical documents in real time, converting doctor's voice into text. The text is entered into the field where the cursor is positioned (for example, a Word document or a medical information system). A doctor dictates the entire description or makes changes to a ready-made template. The use of this product can significantly reduce the time of medical workers to fill in documents. In addition, the functionality of the product includes voice navigation and filling out protocols in medical information systems, voice confirmation of recognition results and the ability to voice control the printing and saving of documents. The program provides support for specialized dictionaries, which allows for accurate recognition and correct processing of medical terms. The program can be used by diagnosticians (ultrasound, CT/MRT/PET CT, Pathomorphology, Radiology, Cardiology, Endoscopy), doctors in clinics and hospitals, and outreach brigades. Speech recognition does not require access to the Internet. The recognition language is Russian [3].

This voice filling system is being actively implemented in medical institutions in various regions. For example, in the Murmansk Oblast, one of the first medical institutions to use the system of voice filling out medical documents was the Murmansk Regional Clinical Hospital named after P.A. Bayandin [4].

TeleMD. Botkin.AI software platform

The Russian company Itellogic, together with the Russian Cancer Research Center named after N. N. Blokhin and other leading scientific and clinical centers, presented the TeleMD software platform, which allows diagnosing and assessing the probability of cancer diseases based on the analysis of medical images and other medical data about a person. An important point for the use of this software product in medical institutions in the Arctic regions is the ability for the attending physician to receive remote consultations with colleagues from the professional community.

An important point is the process of cooperation between medical institutions located in the federal center (Moscow) and in remote territories of Russia. An example of such co-operation is the opportunity for doctors in the Yamalo-Nenets Autonomous Okrug to use the capital's Hub Telemed platform. Radiological examinations of patients from regional clinics can be sent in anon-

[3] Group of companies STC. Program for filling out medical documentation by voice. Voice2Med. URL: https://www.speechpro.ru/product/programmy-dlya-raspoznavaniya-rechi-v-tekst/voice2med (accessed 30 January 2023).
[4] V oblastnoy bol'nitse nachinayut zapolnyat' dokumenty pri pomoshchi golosa [The regional hospital is starting to fill out documents using voice]. URL: https://kn51.ru/2020/01/17/v-oblastnoy-bolnice-nachinayut-zapolnyat-dokumenty-pri/ (accessed 30 January 2023).

ymized form to the platform, where they will be analyzed using neural networks (signs of seven pathologies can be examined at once), the results of which are returned to the doctor for a final description. The use of artificial intelligence technologies does not replace the consulting physician, but increases the accuracy and speed of disease diagnosis, including in the early stages[5].

The Itellogic company, a Skolkovo resident, has also launched a pilot project to use the Botkin.AI platform in the Murmansk Oblast. The platform is a service that can be accessed by any authorized doctor. The platform is based on artificial intelligence technologies to support medical decisions: early detection of oncological (including) diseases, predicting the risks of disease development, and predicting the time when a patient will see a doctor. As part of the pilot project, it was planned to implement integration with the PACS (Picture Archiving and Communication System) system. Incoming medical images would be depersonalized and transferred to the Botkin.AI platform for analysis and recognition of disease foci. The project also included integration with electronic medical records to analyze the risks of disease development. It was planned to connect the Central Archive of Medical Images (CAMI) of the region, functioning on the basis of the Murmansk Regional Clinical Hospital, to the platform [5].

In general, the presented hardware and software complex can be connected to PACS or directly to a data source (CT, PET/CT, MRT, X-ray, fluorography). The list of some tasks solved by the platform includes computed tomography, X-ray, fluorography, mammography and others.

Webiomed predictive analytics platform

Scientists from Petrozavodsk State University (Karelia), together with the K-Sky company, a resident of the Skolkovo Foundation, have developed a unique scientific unit (USU), which can be used by doctors as a medical decision support system. According to the director of the Medical Institute of PetrSU, Alexander Balashov, this is the first hardware and software complex in the Russian Arctic, which includes artificial intelligence technologies, a virtual educational clinic, robots, telemedicine and other modern areas of the healthcare system. The installation allows anticipating possible health risks for patients related to cardiovascular diseases, oncology, lung and bronchial diseases, pregnancy complications [6].

All biomedical data during the provision of medical services to patients (treatment, counselling, etc.) are entered into the medical information system “Unified Digital Platform”, with which medical institutions of Karelia interact. Analysis of the data accumulated in the database allows a doctor to form a diagnostically holistic picture of a patient, on the basis of which treat-

[5] Vrachi Yamalo-Nenetskogo avtonomnogo okruga smogut ispol'zovat' moskovskie servisy iskusstvennogo intellekta [Doctors of the Yamalo-Nenets Autonomous Okrug will be able to use Moscow artificial intelligence services], 30.09.2022. URL: https://advis.ru/php/view_news_ajax.php?id=7A08B789-82EF-9445-8ED0-635F922DE8A5 (accessed 30 January 2023).

[6] Unikal'naya nauchnaya ustanovka: zdravookhranenie Karelii usovershenstvuyut s pomoshch'yu iskusstvennogo intellekta [A unique scientific installation: healthcare in Karelia will be improved with the help of artificial intelligence]. URL: https://rk.karelia.ru/social/science/unikalnaya-nauchnaya-ustanovka-zdravoohranenie-karelii-usovershenstvuyut-s-pomoshhyu-iskusstvennogo-intellekta/ (accessed 30 January 2023).

ment and dynamic monitoring are determined. Moreover, the more data volume will be downloaded and processed by the USU, the higher will be the accuracy of individual recommendations for a particular patient. Biomedical data from other regions, such as Kirov Oblast and Yamalo-Nenets Autonomous Okrug, are used to increase the volume of processed USU databases, and a co-operation agreement has been signed with the Ministry of Health of Murmansk Oblast.

The solution to the problem of medical data processing is based on the use of the Webiomed platform for predictive analytics and risk management in healthcare (developed by K-Sky), which uses such intelligent processing methods as predictive mathematical modeling, machine learning, and NLP technologies for data analysis.

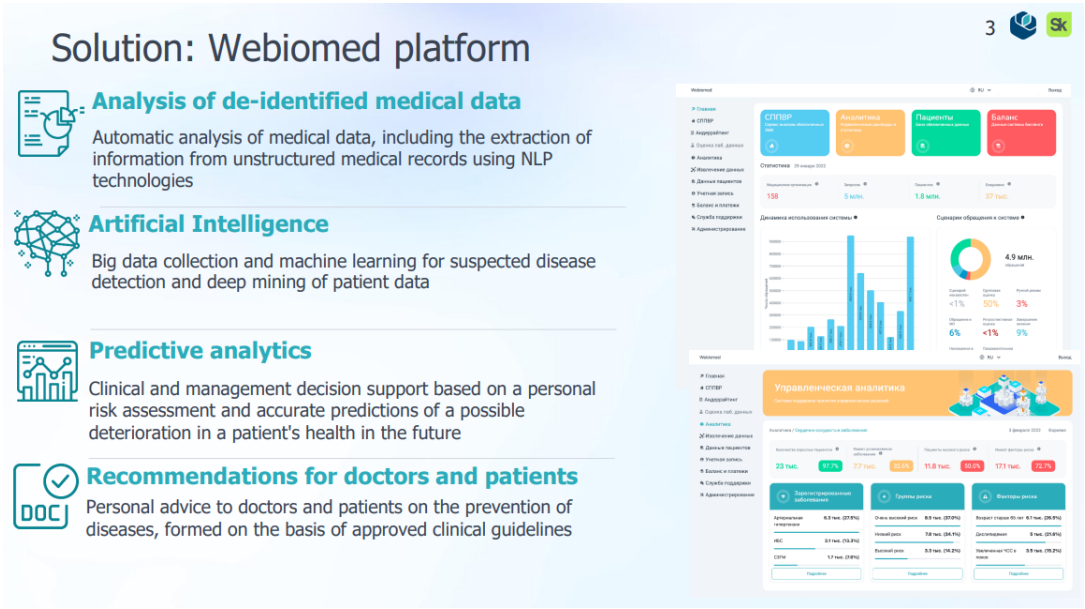

Fig. 1. Webiomed platform [7].

The Webiomed platform was used by the government of the Yamalo-Nenets Autonomous Okrug together with the Association of developers and users of artificial intelligence in medicine "National Medical Knowledge Base" (NMKB) in the project "Implementation of artificial intelligence systems for medicine". According to 2019 data, the project was tested in clinical trials at the Muravlenkovo City Hospital with a large database of electronic medical records.

Some results obtained during the pilot operation of Webiomed:

- accuracy of identifying risk factors and assessing the risk group for cardiovascular disease development by the Webiomed system is 99% (subject to the completeness and correctness of the information submitted for analysis) (the average value of accurate assessment by doctors is 51% of cases);
- correctness of assessment of the absolute risk of death from cardiovascular diseases among patients aged 40 to 65 years: in 37% of medical check-up cards the assessment

[7] Webiomed. Webiomed predictive analytics platform. URL: https://webiomed.ru/ (accessed 30 January 2023).

was correct, in 61% — the assessment was underestimated, in 2% — overestimated (compared to the correct estimate determined by Webiomed);

- correctness of determining the health group. Health group I (patients without chronic non-communicable diseases and associated risk factors, or with a low/moderate risk of CVD mortality): in 9% of cases of patients incorrectly assigned to this health group, the Webiomed platform identified significant risk factors, assigning them high/very high risk degree. Health group II: 15% of misdiagnosed patients with a very high risk and 45% with a high risk of CVD were found [8].

According to 2022, based on the integration of K-Sky and RT MIS software products, a joint project on medical data analysis based on artificial intelligence technologies (Webiomed platform) was implemented in the Republic of Sakha. Within three months, more than 2.8 million impersonal electronic medical documents were analyzed, 18 medical organizations in the region were connected, and about 2000 doctors had the opportunity to work on predicting the development of 40 diseases (CVD, blood diseases, diabetes mellitus, gastrointestinal and respiratory diseases, etc.) [9].

Sciberia software. Pilot project "ONKOPOISKSAKHA.RF"

Sciberia, a resident of Yakutia Technopark and Skolkovo, develops software for analyzing medical images using computer vision and machine learning methods. The products allow solving the problems of diagnosing COVID-19 and acute cerebrovascular accident based on CT examinations of chest or brain [10].

In 2020, the solution proposed by the company was applied to the task of identifying the COVID-19 viral infection in medical institutions in Yakutia. The speed of image processing averaged about 15 seconds, the accuracy of the study was up to 98.5%, while doctors needed at least 30–40 minutes to decipher the CT study [11].

The Sciberia program complex is being implemented in the work of medical institutions of the Republic of Sakha (Yakutia). In addition, healthcare organizations in six regions of the Russian Federation were connected to Sciberia software in testing mode, including the Medical Information and Analytical Center of the Arkhangelsk Oblast [12].

[8] Webiomed. Implementation in the Yamalo-Nenets Autonomous Okrug. URL: https://webiomed.ru/nashi-proekty/yanao/ (accessed 30 January 2023).
[9] Iskusstvennyy intellekt proanaliziroval pochti 3 mln elektronnykh meditsinskikh dokumentov v Yakutii [Artificial intelligence analyzed almost 3 million electronic medical documents in Yakutia]. URL: https://ysia.ru/tsifrovaya-meditsina-v-yakutii-proanalizirovali-pochti-3-mln-elektronnyh-dokumentov/ (accessed 30 January 2023).
[10] SCIBERIA. Healthcare software based on computer vision and machine learning. URL: https://sciberia.ru/#about (accessed 30 January 2023).
[11] Yakutskie uchenye nauchilis' diagnostirovat' porazhenie legkikh za 15 sekund [Yakut scientists have learned to diagnose lung damage in 15 seconds]. URL: https://ysia.ru/yakutskie-uchenye-nauchilis-diagnostirovat-porazhenie-legkih-za-15-sekund/https://ysia.ru/yakutskie-uchenye-nauchilis-diagnostirovat-porazhenie-legkih-za-15-sekund/ (accessed 30 January 2023).
[12] Yakutskaya kompaniya «Sayberiya» sozdala mnogomestnuyu rabochuyu stantsiyu na baze «El'brus 16S» [The Yakut company "Siberia" has created a multi-seat workstation based on the "Elbrus 16S"]. 2023. URL: https://www.cnews.ru/news/line/2023-01-31_yakutskaya_kompaniya_sajberiya (accessed 30 January 2023).

With the support of the Ministry of Health of the Russian Federation, a pilot project "ONKOPOISKSAKHA.RF" has been developed in the Republic of Sakha (Yakutia), which allows the use of artificial intelligence technologies in preventive medicine of oncological pathologies. The project has an official website.

The questionnaire filled in by the patient is evaluated by trained neural networks, and in the case of a high risk of oncology, a recommendation to make an appointment at a medical institution, including instrumental and laboratory tests at the Yakutsk Republican Oncological Dispensary, is issued [13].

Digital FAP mobile diagnostic software system

In 2022, testing of the hardware and software complex for mobile diagnostics "Digital FAP" by SberMedII was carried out in the Murmansk Oblast. It is a compact case, safe for transportation and storage, the basic set of which includes the necessary diagnostic equipment.

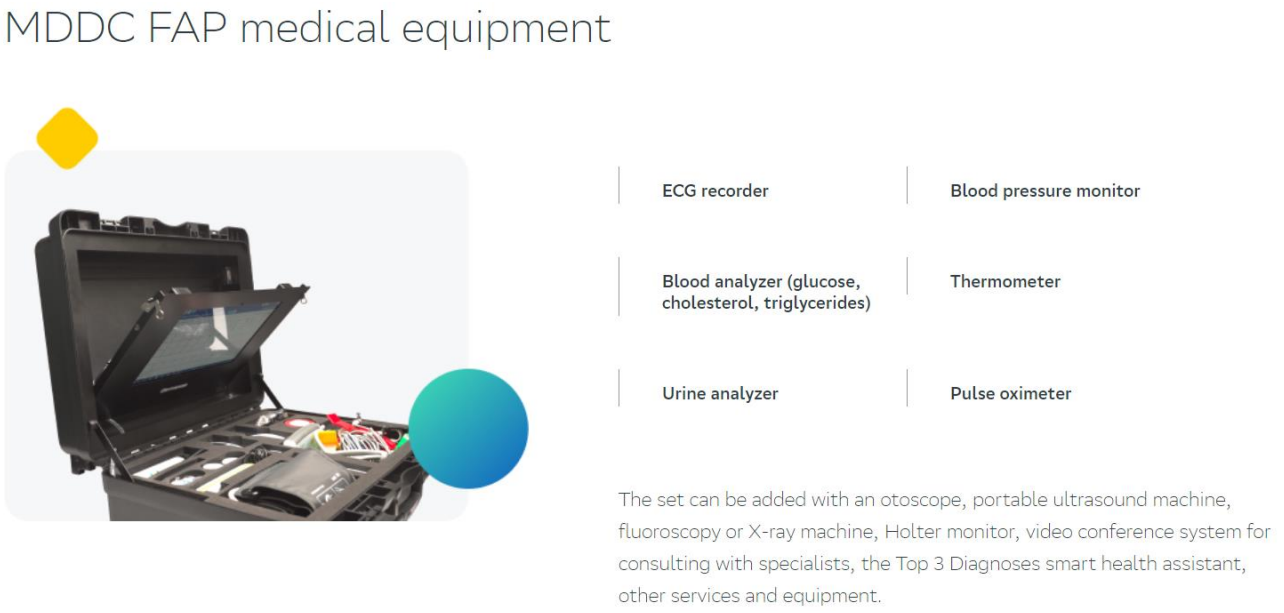

Fig. 2. Digital FAP. Medical equipment.

The complex is integrated with the Medical Digital Diagnostic Center and, working on artificial intelligence algorithms, allows deciphering and routing data received from devices [14]. It should be noted that as of 2022, the platform of the Medical Digital Diagnostic Center united more than 50 SberMedII solutions (including "CT Lungs", "CT Stroke", "TOP-3" Smart digital medical assistant based on AI) and services of partner companies.

[13] SBERMED AI Iskusstvennyy intellekt v rossiyskoy sisteme zdravookhraneniya [SBERMED AI Artificial intelligence in the Russian healthcare system]. 2022. URL: https://sbermed.ai/en/iskusstvenniy-intellekt-v-meditsine-rossii/ (accessed 30 January 2023).

[14] SBERMED AI. Digital FAP. URL: https://sbermed.ai/diagnostic-center/meditsinskoye-oborudovaniye-s-ii/fap/ (accessed 30 January 2023).

Fig. 3. Digital FAP. Work principles.

Thanks to the ability of connecting to services based on artificial intelligence algorithms, residents of remote and hard-to-reach areas can not only undergo examinations, but also receive scheduled or emergency consultations with relevant specialists of regional hospitals. At the same time, there is a high speed of obtaining the results of laboratory and instrumental studies in real time and their automatic entry into the patient's electronic record [15].

Conclusion

"Digital health", defined today as "cultural transformation in healthcare", is designed to solve many problems of providing medical services, including in institutions in the Arctic regions of the Russian Federation. Difficult climatic conditions, territorial remoteness and distribution of regions, insufficient provision of medical personnel and equipment cause such problems as reduced life expectancy of the population, high level of infectious diseases, etc. [16] The solution to these problems can be found in the use of advanced technologies related to digitalization and informatization of healthcare.

Undoubtedly, one of the most advanced areas is IT solutions developed on the basis of artificial intelligence technologies. Already today, artificial intelligence makes it possible to analyze skin condition using a smartphone, to analyze a person's condition using a video selfie, to measure a person's blood pressure using an ordinary camera, to carry out the initial diagnosis of severe neurodegenerative diseases on the basis of the analysis of the patient's speech, to determine the degree of risk of developing atherosclerotic cardiovascular diseases within 10 years on the basis of a chest X-ray, to predict the development of such diseases as dementia, Alzheimer's disease and many others based on the results of brain activity, and much more [17].

An important point is the study and use by regional medical institutions of advanced digital medicine practices operating on machine learning and computer vision algorithms. Prompt and

[15] Information agency "B-port" News of Murmansk and the Murmansk Oblast, 2022. URL: https://b-port.com/news/273748 (accessed 30 January 2023).
[16] Evercare. Digital health in the Arctic. URL: https://evercare.ru/news/cifrovoe-zdorove-v-arktike (accessed 30 January 2023).
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accurate examinations, higher quality of medical care should be the prospects of introducing artificial intelligence into the healthcare system.

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