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TELEMEDICINE AS AN ESSENTIAL PART OF THE MODERN HEALTHCARE DEVELOPMENT

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ABSTRACT — Widespread use of telemedicine as a method for remote medical care provision can become one of the most promising ways to optimise modern healthcare. This article proposes a methodology for adult health telemedicine screening using a system for analysing unstructured data of monitoring chronic non-communicable diseases in the population. This method is based on the risk estimation by the Decision Rules approach, and the fuzzy set theory is used as a description tool. Scientifically-based comprehensive clinical approach for the development of medical questionnaires, the knowledge of which depends on a large scientific base in the field of screening, propaedeutic, taking into account the standards and requirements of health assessment in the Russian Federation, is a fundamental difference from the existing analogues. Expert system of telemedicine questionnaire screening allows determining the health risks by specific profiles, to develop a final personalised judgment with recommendations for a healthy lifestyle, further examination, treatment, and prevention of chronic non-communicable diseases.

KEYWORDS — telemedicine, screening, chronic diseases, health protection, quality improvement in healthcare, information and communication technologies (ICT).

BACKGROUND

Currently, there is a steady increase in public spending related to healthcare worldwide. Widespread introduction of telemedicine in general practice as a method for provision of qualified remote medical care is one of the promising options for optimising such costs.

Telemedicine has existed for a long time one way or another. E.g., in 1905, Einthoven first transmitted ECG records using telephone communication. Since 1922, the University Hospital in Gothenburg has been providing medical consultations to seafarers via radio channels. In 1959, the first television consultation of a psychiatric patient was held in the United States. Later in 1965, the American cardiac surgeon, M. Debeki, consulted surgeons, performing a surgery in Geneva, via a satellite communication channel. In 1999, Ms Gerry Nielsen, engaged as a medical specialist at the Amundsen-Scott Research Station in Antarctica, was diagnosed with and treated for breast cancer through satellite communication, email, and video conferencing. [1].

According to WHO, the term *telemedicine* defines health services provision in conditions where the distance is a critical factor by healthcare professionals, using information and communication technologies (ICTs) to exchange the necessary data for the diagnosis, treatment and prevention of diseases and injuries, conduct research and assessments, as well as to continue the education of health professionals for the improvement of public health and the development of local communities [2]. In turn, the European Commission considers this term more specifically and proposes to construe telemedicine as operational remote access to the services of medical specialists, using ICTs, regardless of the patient location or the way the relevant information is stored. [EHTEL, 2008]. According to the definition of the American Telemedicine Association (ATA), telemedicine is the use of medical information provided by one party to another by electronic means of communication to improve the health of patients. [3] Despite the fact that each institution offers its own interpretation of the term, each of the definitions highlights three main characteristics of telemedicine: health care quality improvement, the use of ICT, and remote access. [4].

In 2010, WHO identified four specific principles of telemedicine [WHO 2010]: provision of clinical support, overcoming geographical barriers and establishing communication between physically distant users, using various ICTs, improvement of public health [2].

SYNCHRONOUS AND ASYNCHRONOUS TELEMEDICINE

Telemedicine, depending on the terms of information transmission and interaction between the persons involved in the process, can be divided into 2 types: synchronous and asynchronous [2]. Asynchro-

nous telemedicine is based on the exchange of pre-recorded data between two or more persons at different periods of time. For example, the sending a clinical case to an expert via email with subsequent doctor's feedback on the diagnosis, optimal therapy, and recommendations for a healthy lifestyle management can serve as the examples of asynchronous telemedicine, Synchronous telemedicine is applicable in real time and requires simultaneous presence of participants in the process, e.g., during video conferences, phone conversations or via the Internet. In both synchronous and asynchronous telemedicine, information can be transmitted in various forms: as text, audio, video, or image [5].

REMOTE MONITORING AND COVID-19

Remote monitoring can be singled out separately. This is a form of telemedicine that involves remote monitoring of the patient's condition by medical professionals using various technical devices. The data obtained during monitoring is subject to remote monitoring and is transmitted to a medical facility for further analysis and interpretation. [4, 6] Remote monitoring is used for dynamic observation of patients with cardiovascular diseases, diabetes mellitus, bronchial asthma, as well as for domiciliary patients monitoring. [3]

The use of modern technologies now makes it possible to provide high-quality medical care without violating the principles of social distancing, which is really important in the context of the COVID-19 pandemic, where telemedicine has become the first line of defence for both patients and medical specialists. [7] As practice has shown, telemedicine can be used in several forms in conditions of global quarantine [7]:

1. Online consultations: tele- and video conferences;
2. Telemonitoring: the use of screening devices, which assess the level of blood pressure, saturation as well as the respiratory rate;
3. Chatbots, where the patient can get answers to frequently asked questions, as well as request connection with the doctor.

Nowadays, telemedicine combines convenience, low cost, and high availability for the end user. As a result, it reduces the time for diagnosis and treatment, including in the context of the COVID-19 pandemic, as well as possibility of close observation without necessity of moving around the city, and direct physical contact with a medical professional, which ultimately reduces the risk of spreading the infection. In addition, telemedicine can be used to control the spread of both non-communicable and infectious diseases, including COVID-19 [8, 9, 10].

Recent events related to the COVID-19 pandemic, forced self-isolation regime, cancellation of face-to-face appointments and re-profiling hospitals have given impulse for development of telemedicine in Russia. The population began to show more and more interest in telemedicine, considering that after the beginning of COVID-19 the need for medical consultations did not disappear, but, on the contrary, increased. Thus, in 41% of cases, a face-to-face consultation was not required after a remote request for medical care, 20% of those who applied were re-admitted to the same specialist and in 30% of cases, and patients were immediately referred to a narrow-profile specialist without another consultation with a therapist [11].

TELEMEDICINE MARKET AND SERVICES

Currently, the development of telemedicine services is an absolute trend in the development of the digital industry worldwide. According to various estimates, the average annual growth rate of recently emerging online medical opportunities for users in the next five years will be about 116%. If the volume of the Russian telemedicine market was estimated at RUB 1.5 bln in 2019, it is expected to grow more than 60 times by 2025, reaching RUB 96 bln, which is consistent with the VEB Ventures opinion. At the same time, the company notes that the growth driver will be not just the service demand dynamics effect, but also the availability of telemedicine platform services for a wide range of patients [12, 14].

In terms of the global market, according to BBC Research, the global telemedicine market increased to an average of $44 bln in 2019. According to P&S Market Research in 2016, its volume did not exceed $18 bln. Lower market activity in developing countries is related to insufficient payback and lack of technological infrastructure. In developed countries, telemedicine complements traditional medicine, while in developing countries telemedicine is often an alternative to traditional medical care. Despite this fact, the emergence of telemedicine in developing countries opens up access to health services for a wide range of people, as well as reduces geographical barriers [12].

We analysed the market of companies, developing telemedicine, and found 35 services, and almost all of them interact with the client by means of a video camera (video service), smartphone, or computer [13–20]. The price of such services in the foreign market ranges from $5 per month to $441 per insurance package per year. For comparison, in 2020, the average check in private clinics in the Russian Federation was amounted

to RUB 3,000 (€33) per visit, and the average cost of a minimum check-up: therapist's appointment, blood and urine tests, lung X-rays and ECG was amounted to RUB 40,000 (€442). The price of a specialist consultation using telemedicine technologies on the Yandex-Health portal starts from RUB 499 (€5.5). The main type of services provided is the patient flow control, remote telemedicine counselling, and signal processing from gadgets [21].

Thus, in terms of cost-effectiveness, it is obvious that the introduction of telemedicine will reduce health care costs [22, 23]. The reduction in health care costs will be achieved by reducing the cost of hospitalisation, patient transportation, and indirect costs associated with leaving home or office [24]. Thus, a number of Russian and foreign studies have shown a reduction in costs for telemedicine in comparison with traditional methods from 2 to 73%. Even now, telemedicine consultations for the end user have become over 10 times more profitable than face-to-face consultations [22, 25].

Thus, there are all the prerequisites for the emergence of own developments using telemedicine technologies in Russia. However, among the well-known programs, along with their undoubted advantages, such as accessibility to the public, possibility of remote examination, relatively low cost of screening, there are also disadvantages such as lack of final analytical documents, coverage of one or more systems, need for a face-to-face visit to the doctor to estimate the risks and determine further tactics of patient control [26].

MATERIALS AND METHODS

We have developed our own version of telemedicine questionnaire screening for adult health, based on the experience of national and foreign colleagues. The scientific-based comprehensive clinical approach to the development of the medical questionnaire, the knowledge of which is based on a large scientific base in the field of screening, propaedeutic, taking into account the standards and requirements of the health assessment of the Russian Federation, is a fundamental difference from the existing analogues. Creation of a decision tree model and development of algorithms for risk share estimation, taking into account external factors, including the specifics of the residence halo, cultural characteristics of nutrition, and others, will improve the quality of medical screening, its reliability, and will also make it possible to give the user optimal recommendations on the strategy of diagnosis and treatment. Over the past year and a half, the authors have done a great deal to create a telemedicine system of questionnaire screening, a methodology for selection and ranking of questions that are most informative, simple and available for stating, taking into account an integrated approach [27, 28].

The study was conducted at the Department of Internal Medicine, Clinical Pharmacology and Nephrology of the North-Western State Medical University named after I.I. Mechnikov, based on our platform for telemedicine medical support. The study involved 139 people: 97 women and 42 men, the average age of the subjects was 65±13.8 years.

We did not use a clinical entity as a health risk assessment in the telemedicine system, but rather a pathology profile, in which a set of analytical features, objective examination data, and complaints were divided into groups. 198 questions were prepared for conducting a multidisciplinary comprehensive questionnaire health screening; these questions were structured according to 5 pathology profiles: cardiology, endocrinology, gastroenterology, pulmonology, and oncology. These pathology profiles were not chosen by chance: Since the second half of the 20th century, the main death causes have been chronic non-communicable diseases (chronic NCDs): circulatory illnesses, chronic bronchopulmonary diseases, oncological diseases, and diabetes mellitus. In the Russian Federation, about 75% of all deaths occur annually due to chronic non-communicable diseases, however, particularly high mortality is observed among people of working age [29]. In addition, the prevalence of digestive diseases has increased in recent years [30].

RESULTS AND DISCUSSION

All the fairly ascertained features of each profile were evaluated according to the degree of their severity or the reliability of their presence. Minimal deviations were taken for early detection of pathology or low risk, in cases of its combination with any complaints or developmental features noted in the questionnaire. The program provides both identification of the severity degree and attribution of the symptom or sign to the pathology of several systems, since they can often appear during destruction of different organs, and therefore the estimation of the disease risk spectrum is carried out by the system in accordance with all five profiles. In turn, the system is configured for the boundary between the risk group and the pathology, estimated at 50 points, and the range of the risk group is concentrated in the range from 20 to 50 points. The risk estimation is carried out by the *Decision Rules* method, and the fuzzy set theory is used as description. The typical features of the mathematical apparatus used are, on the one hand, the ability to formalise ideas about the degree of severity of a particular symptom, and on the other hand, the adequacy of medical logic.

Using the developed technology, it was found that 33.8% of the subjects were diagnosed with a low risk of cardiovascular diseases, 41.7% — an average risk, 24.5% — a high risk. While analysing the answers to the questions of the gastroenterological profile, 33.1% had a low risk of gastrointestinal diseases, 46.8% had an average risk, and 20.1% had a high risk. 46.7% of the subjects had a low risk according to the *Pulmonology* profile, 40.3% had an average risk, and 13% had a high risk. 6.5% of the respondents were diagnosed with low risk in the *Endocrinology* profile, 23.7% were diagnosed with medium risk, and 69.8% were diagnosed with high risk, however, this profile requires further development due to the non-specificity of endocrinological complaints. 18% of the subjects have a low risk of cancer, 32.4% have an average risk, and 49.6% have a high risk of cancer, according to the questionnaires, which requires increased cancer alertness in this study group. The average score of the subjects in the cardiological profile was 517, in the gastroenterological profile — 440, the average value in the *Pulmonology* profile was 439, the average value in the *Endocrinology* profile was 495, and the average value in the *Oncology* profile was 533. 12 subjects (8.6%) were revealed to have a high risk in all 5 pathology profiles. And only 7 (5%) of the examined patients were diagnosed with a low risk for all pathology profiles.

The program analysed the obtained data and offered appropriate recommendations depending on the age, gender, body mass index, vicious habits, and level of physical activity and identified risk factors of the subject. Thus, in case of a low risk of disease development in all 5 pathology profiles, it is recommended to follow healthy lifestyle rules, including the principles of proper nutrition, body weight control, sufficient physical activity, rejection of vicious habits and medical examinations according to the established deadlines. In case of an average risk of disease development, depending on the pathology profile, in addition to the healthy lifestyle, it is recommended to monitor blood pressure daily, as well as to determine a set of necessary laboratory and instrumental examinations, and immunisation. In case of high risk of pathologies, the program recommends a full-time consultation with a doctor to determine the further strategy of examination and treatment of such a patient, as well as a dispensary follow-up with an appropriate specialist at the place of residence.

CONCLUSION

Thus, our program makes it possible to determine the degree of existing health risk by specific profiles (cardiology, gastroenterology, pulmonology, endocrinology, oncology), to develop a final judgment and recommendations for a healthy lifestyle, further examination, treatment and prevention of chronic diseases.

The innovation of this development lies in in-house methodology for the selection and ranking of clinical symptoms and signs of diseases, taking into account their severity and reliability. The specified symptoms and signs of diseases create not a clinical entity, but a pathology profile, and therefore they have the greatest information content, statement availability, and cover all the key body systems. Moreover, an original case of summary documents with recommendations on lifestyle changes has been developed.

The benefits of this development are the flexibility of the decision rules, corresponding to the opinion of the expert doctor, the convenience and clarity of the representation of the final results, the formulation of conclusions on the necessary follow-up and recommendations for adherence to a healthy lifestyle, as well as individualised approach, mobility, absence of reference to time and place, and the availability of *doctor–patient* feedback.

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