Modern medical technologies as a prevention of health protection and improvement of fitness in patients of different age

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Abstract
In recent years, along with the development of IT, telecommunication and digitization, there has been a development of telemedicine as one of the most modern methods of providing medical services or medical care itself, in order to monitor patients 24 hours a day, also remotely, without leaving home. Telemedicine methods focus mainly on the care of the elderly, disabled and dependent people. In the current situation of the Covid 19 pandemic, it has also become the only possibly safe form of contact between the patient and the doctor. Telemedicine is currently dynamically developing in: cardiology, diabetology, physiotherapy, as 24/7 tele - home care. Modern systems used in telemedicine allow for 24-hour monitoring of the patient's vital parameters, such as: heart rate, blood pressure, temperature, glucose level, saturation, thanks to which it is possible to control the risk of fainting, falls and sudden death.

In the current situation, related to the Covid 19 pandemic, telemedicine systems are gaining an upward trend among the elderly group, as a prevention against falling ill, but also provides psychological comfort and gives the patient and his family a sense of security. Thanks to modern technology and the development of digitization techniques, telemedicine allows for medical control, diagnostics, prophylaxis, prevention and treatment of the patient at a considerable distance.

One of the first and innovative technologies used in medicine was the performance of a surgical operation in 2001 by prof. Jacques Marescaux from New York on a 68-year-old woman staying in a hospital in Strasbourg, 6500 km away. The operation was performed with a modern device called Zeus and became a milestone not only in remote telerobotics but in the development of all medicine.

Key words: elderly people, chronic diseases, 24-hour care, telemedicine

Анотація
Каміла Макулець, Радослав Мушкієта, Ева Кічке, Валерій Жуков, Магдалена Хагнер-Деренговська. Сучасні медичні технології як профілактика збереження здоров'я та підвищення працездатності пацієнтів різного віку
В останні роки разом з розвитком ІТ, телекомунікацій та цифровізації спостерігається розвиток телемедицини як одного з найсучасніших методів надання медичних послуг або самої медичної допомоги, з метою цілодобового спостереження за пацієнтами, також дистанційно, не виходячи з дому. Методи телемедицини зосереджені переважно на догляді за людьми похилого віку, інвалідами та залежними людьми. У нинішній ситуації пандемії Covid 19 це також стало єдиною, можливо, безпечною формою контакту між пацієнтом і лікарем. Нині телемедицина динамічно розвивається в: кардіології, диабетології, фізіотерапії, як цілодобовий теле-догляд на дому. Сучасні системи, що використовуються в телемедицині, дозволяють цілодобово відстежувати життєво важливі параметри пацієнта, такі як: пульс, артеріальний тиск, температура, рівень глюкози, сатурація, завдяки чому можна контролювати ризик непритомністі, падіння і раптової смерті.

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У нинішній ситуації, пов’язаної з пандемією Covid 19, системи телемедицини набувають тенденції до зростання серед літньої групи, як профілактика захворюваності, але й надають психологічний комфорт та дають пацієнту та його родині відчуття безпеки. Завдяки сучасним технологіям та розвитку техніки оцінювання, телемедицина дозволяє здійснювати медичний контроль, діагностику, профілактику та лікування пацієнта на значній відстані.

Однією з перших і інноваційних технологій, що використовуються в медицині, стало виконання хірургічної операції у 2001 році проф. Жак Мареско з Нью-Йорка на 68-річній жінці, яка перебувала в лікарні в Страсбурзі, за 6500 км. Операція була виконана за допомогою сучасного приладу під назвою Zeus і стала віхою не тільки в дистанційній телеробототехніці, але і в розвитку всієї медицини.

Ключові слова: люди похилого віку, хронічні захворювання, цілодобовий догляд, телемедицина.

Резюме
В последние годы, наряду с развитием информационных технологий, телекоммуникаций и оцифровки, развивалась телемедицина как один из самых современных методов предоставления медицинских услуг или самой медицинской помощи, позволяющий контролировать пациентов 24 часа в сутки, в том числе удаленно, не выходя из дома. Методы телемедицины ориентированы в основном на помощь пожилым людям, инвалидам и иждивенцам. В нынешней ситуации пандемии Covid 19 это также стало единственной возможной безопасной формой контакта между пациентом и врачом. В настоящее время телемедицина динамично развивается в таких областях, как кардиология, диабетология, физиотерапия, а также круглосуточный удаленный уход на дому. Современные системы, используемые в телемедицине, позволяют круглосуточно контролировать жизненно важные параметры пациента, такие как: частота сердечных сокращений, артериальное давление, температура, уровень глюкозы, сатурация, благодаря чему можно контролировать риск обморока, падений и внезапной смерти.

В текущей ситуации, связанной с пандемией Covid 19, системы телемедицины приобретают все большую популярность среди пожилых людей в качестве профилактики от болезней, но также обеспечивают психологический комфорт и дают пациенту и его семье чувство безопасности. Благодаря современным технологиям и развитию методов оцифровки телемедицина позволяет осуществлять медицинский контроль, диагностику, профилактику и лечение пациента на значительном расстоянии.

Одной из первых и инновационных технологий, использованных в медицине, стало проведение хирургической операции в 2001 г. проф. Жак Мареско из Нью-Йорка о 68-летней женщине, находящейся в больнице в Страсбурге, в 6500 км. Операция была проведена на современном устройстве под названием Зевс и стала важной вехой не только в дистанционной телеробототехнике, но и в развитии всей медицины.

Ключевые слова: пожилые люди, хронические заболевания, круглосуточная помощь, телемедицина.

Medical technologies in senior care
There has been a dynamic development of new technologies used in medicine all over the world. Modern apparatuses and medical equipment are used in medical care, especially of the elderly, as this population is growing rapidly. A new interdisciplinary branch of science developed - Gerontotechnology. It is a field initiated already 20 years ago. It deals not only with the problems of the elderly in society or the environment, but also with the skilful application of measures facilitating the access of this age group to any infrastructure facilities [1]. It constitutes the creation, development, implementation and application of new medical technologies in various areas of senior life. Particular attention is paid to technologies and equipment used in welfare and medicine. The development of new technologies is increasingly becoming a strategic element in the
world. Examples include the Swedish government program Teknik för Äldre (“Technology for the elderly”) or Nationell e-hälsa Strategin (“National eHealth Strategy”). The importance of using new technologies in the service of seniors was also noticed by the European Commission, which in 2007 published an action plan entitled: “Comfortable functioning of older people in the information society: Action plan on ICT and aging of society” [2].

Telemedicine has now achieved application in virtually all branches of medicine. However, the largest social group that uses technical innovations and for which newer and newer solutions are being adapted are the elderly. This can be explained by a significant increase in the aging of the population in the world with, at the same time, a low increase in births. Considerable progress in medicine, improvement of hygienic, sanitary and epidemiological conditions, increase in public health awareness, greater emphasis on maintaining physical fitness, physical activity, prophylaxis and popularization of screening tests result in the extension of the average human life span. In 2010, the average life expectancy for men was 72.1 years, and for women it was 8.5 years longer and amounted to 80.6 years. Compared to the beginning of the 1990s, life expectancy has now increased by almost 6 years for men and by 5.4 years for women (in 2000, this parameter was: for men - 69.7, for women - 78.0 ) [3]. Societies are aging, and demographic forecasts indicate that in the coming years the percentage of people aged over 65 will significantly increase throughout Europe and in 2050 it will reach 31.3% of the total population [4]. In addition, age-related, much more frequent occurrence of chronic diseases and their effects causes a constant increase in the demand for medical services and a proportional increase in financial outlays for health care. As shown by the statistics in most European countries, including Poland, the expenses incurred by the medical care system for the diagnosis and treatment of patients suffering from chronic diseases are significantly increasing every year [5].

Telecardiology.

Cardiovascular illnesses have become diseases civilization diseases all over the world. Unfortunately, Poland is in the leading position among the European Union countries. Nowadays, there is an upward trend in the incidence of cardiovascular diseases among increasingly younger people. It is caused by the use of stimulants, poor diet, seated lifestyle, especially at work, where movement has been converted into sedentary work as a result of remote job and the extensive development of computerization. Young people do not have to leave home to earn a living, they can work remotely at the computer. Social meetings are "celebrated" on social networks, which also does not have a positive effect on the entire human body and the cardiovascular system. Nowadays, work is also associated with stress, which, together with a lack of exercise, causes a high risk of heart disease. Taking into account growing trend of aging of the society, it would seem that the diseases mentioned concern only the elderly, who additionally suffer from other care for the elderly. An elderly person who wants to remain under medical care must perform a number of activities that often exceed their physical and mental capabilities, especially when they live alone and have no family support. Very often, even getting to the hospital becomes a problem. Using public transport (problems with getting in and out of the vehicle), waiting in queues for many hours for registration, for additional tests, outdated hospital infrastructure, not adapted to the needs of the elderly, is quite a big obstacle. In recent years, especially in Poland, many months of waiting for specialist consultations have become a serious problem [6]. Telemedicine, which enables the simplification and speeding up of the necessary medical procedures, comes out to meet the requirements of this age group. The patient has access to attending a physician and other specialists regardless of where they are, and the necessary tests can be performed at any time of the day or night. The possibility of direct, quick access to medical services, conducting urgent consultations without leaving home and waiting in long queues to specialists' offices makes telemedicine modules an extremely convenient solution for seniors and people with disabilities [7].
diseases that have a negative impact on heart, e.g. diabetes, hypertension, excess weight [8].

Telecardiology allows for constant, remote monitoring of the patient's vital functions, regardless of their current location (home, workplace, medical center, or even another country). It enables, among other things, a 24-hour blood pressure measurement or real-time electrocardiogram (EKG) performance. Thanks to such designed solutions, the doctor can constantly monitor the health of his patient, and in the event of an emergency, e.g. an acute coronary incident, he has a chance for a quick reaction, which in many cases may save the patient's life. There are over a dozen of centers in Poland that enable remote ECG performance, such as the Cardiac Surveillance Center KARDIOFON, MONTE Cardiac Monitoring, Kardiotel Medical Center, Telekardiomed, DIAMED Systems and others. Telemedycyna Polska S.A. is one of the precursors and leaders of modern telemedicine methods in the field of cardiovascular disease prevention. During the WallStreet 16 Conference, at the time of the New Markets Day (May 31 - June 3, 2012), the company organized a Mobile Cardiology Clinic for about 70 participants of the meeting. Each of them had an electrocardiogram with the use of a modern, 12-lead, digital ECG apparatus, which enabled data transmission over a distance. The ECG, sent online to the cardiac monitoring center, after the doctor's interpretation, was returned with a description to the conference, and its result was printed and handed over to the participant of the study. The results of this experimental study turned out to be surprising.

Among approximately 30% of the examined people, there were detected irregularities in the record, requiring in-depth cardiological diagnostics. The simulation of the operation of the telemedicine system clearly shows the need to increase the patient's availability to technologies, enabling early detection of heart diseases and the implementation of preventive measures. Using the cardiac surveillance system is simple and should not be difficult even for the elderly. In order to perform a standard heart examination, the patient attaches disposable electrodes to the body connected to the EKG machine, and then dials the phone number of the cardiac monitoring center. On the other side, he is greeted by the voice of the doctor on duty, then the patient activates the device and places it on the telephone receiver. In the Surveillance Center, a record of the patient's heartbeat is displayed on the computer screen, on the basis of which the doctor, after collecting the necessary medical history, recommends further treatment of the patient. If the result of the test requires it, the ambulance service is called to the patient, providing the dispatcher with information about the patient's illness, medications taken and the current health condition [8].

**Telediabetology**

Among many challenges met by telemedicine is monitoring in the prevention and diagnosis of diabetes. This chronic disease affects 171 million people worldwide, and by 2030 this number is estimated to rise dramatically to 366 million. A large number of patients in this group are people over 65 [1]. WHO regularly reports on the dynamics of the increase in the incidence of diabetes and warns that by 2030 diabetes may become the 7th most common cause of death in the population. According to the statistics of the International Diabetes Federation, 11 people in the age group 20-79 suffer from diabetes. Untreated or improperly treated and uncontrolled diabetes can lead to numerous complications such as diabetic ketoacidosis, hyperglycemic-hypermolar state, hyperglycemia and chronic syndromes such as diabetic foot, diabetic kidney disease, diabetic eye disease, myocardial infarction, heart failure, stroke, which lead to permanent disability and even death. Currently, innovative solutions are sought all over the world that will reduce the risk of developing diabetes and its complications, and reduce or decrease in the burden on the budget for the treatment of this group of patients. Telemedicine in diabetology is a proven solution confirmed by clinical trials and is recommended by the entire diabetic medical community around the world [9]. Among health services provided in the form of telemedicine crucial role play: online consultation with a diabetologist, remote monitoring of the course of diabetes and teleducation.
### Table 1.

**Type of telecare in diabetology and its benefits**

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<th>Type of telecare</th>
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| **Telephone consultation** | - Possibility of lowering the HbA1c parameter in patients with type 1 and type 2 diabetes during the use of remote counseling.  
- The possibility of replacing some of the routine stationary visits with telemedicine consultations.  
- Possibility to supplement standard clinical care in order to improve HbA1c among both patients with type 1 and type 2 diabetes, especially during interactive forms of contact with the patient.  
- Promising results in the reduction of excess body weight (obesity treatment) with the simultaneous support of medical professionals, nutritionists and cardiologists.  
- Possibility of positive effects of diabetes self-control at the stage of primary medical care. |
| **Remote Monitoring of diabetes course** | - In terms of the use of CGM and FGM (isCGM), it has been shown that CGM breaks geographic barriers, which allows access to medical services at a greater distance and glycemic control using a telephone.  
- More frequent communication with professionals on a smartphone improves patients' understanding of the underlying condition of their disease.  
- The use of CGM is possible for both older and younger patients. The use of CGM reduced the time spent in hypoglycaemia from 73 minutes to 39 minutes a day.  
- The use of FGM (isCGM) in daily diabetes care reduces and maintains the value of HbA1 in elderly patients with type 1 and 2 diabetes and children with type 1 diabetes.  
- The research showed the possibility of improving the parameters in the first 2 months of using the device and maintaining it for the next year.  
- The use of FGM (isCGM) reduces the episodes of hypoglycaemia and the HbA1 value in patients.  
- The achieved effect of the decrease in glycemic disturbances and the obtained improvement in glycemic markers were maintained in the patients over the period of 6 months, which indicates the long-term benefits of using the device. |
| **Comprehensive care due to online consultation and remote monitoring services.** | - Obtained a significant improvement in HbA1c rates, a drop in blood pressure - in one study from 1142 / 71mm Hg to 137/68 mmHg, and the level of LDL cholesterol, compared to standard care.  
- Improving the metabolic control of diabetes through the use of videoconsultation with a doctor and nurse.  
- More effective determination of the optimal insulin dose with the help of telemedicine, as well as the use of mHealth and diabetes e-education contribute to the improvement of glycemic control and the quality of patients’ life.  
- Significantly better results in diabetes control among patients with type 2 diabetes and among elderly patients who use telemedicine methods for a long time. |

Remote interventions and medical consultations can give as good results in the treatment and monitoring of a patient as in person contact with a doctor. Under the name of the above-mentioned CGM and FGM (isCGM) systems, standard blood glucose meters with strips and dedicated applications are used in diabetology. There are also special insulin pens and pumps that can be used as a source of data from patients. For this purpose, applications that enable the integration and transfer of data from the patient to the healthcare provider should be promoted. Telemedicine techniques, thanks to the use of relatively simple teleinformation systems, make it possible to measure blood glucose levels, and then send data from the meter to a central database and then to a medical center for interpretation by medical personnel. Information is sent to a mobile phone or computer over wireless networks, a standard dial-up modem, or the Internet. The patient then receives feedback in the form of a text message or e-mail with instructions on how to proceed, and in urgent cases by phone. All information about the patient is archived. These data is an available source of knowledge on diabetes control and on the basis of them, it is possible to modify the treatment, exercise program and diet depending on the current blood glucose levels. [6]. In the USA, advanced smartphone applications are available that, in addition to constantly monitoring blood glucose levels, allow for e.g. recording of insulin dose, carbohydrate intake,
physical activity, body weight, blood pressure, coding of hyperglycemic or hypoglycemic states, triggering drug reminder alarms and adjusting operation of insulin pumps. The most popular applications include: Diabetes Buddy, Diamedic, WaveSense Diabetes Manager [18].

Many publications on telemedicine systems used in diabetes monitoring indicate a much better degree of diabetes control (decrease in glycosylated hemoglobin concentration), greater awareness of the essence and consequences of the disease, a better level of cooperation and mutual trust between patients and doctors in comparison to patients who do not use this system, which in consequence gives better control of the disease and improves the patient’s quality of life. [7].

Telerehabilitation
Telerehabilitation has developed as one of the first branches of telemedicine. It is used in cardiology, orthopedics, hearing and speech rehabilitation, neurology and psychiatry. The majority of patients requiring comprehensive rehabilitation are people over 60 years of age.

The first research papers describing the impact of telerehabilitation on the speed and degree of recovery of patients come from the 1990s and concern patients suffering from cardiological diseases. The first medical articles on modern wireless sensors for monitoring the body and physiological changes occurring in the human body and affecting the life or health of the elderly and chronically ill were published as early as 2005.

Thanks to technological advances in the functioning of integrated circuits and wireless communication, it is possible to detect physiological changes using light, miniature and very energy-saving monitoring devices. Many of these devices can be integrated into the Wireless Body Area Network (WBAN), the development of which allows monitoring of the patient’s health.

Fig. 1. Wireless Body Area Network of Intelligent Sensors for Patient Monitoring
All recorded information is sent to the medical service via the Internet and transferred in the form of electronic documentation. One of the first such small and accessible devices for chronically ill people is the Holter device, used among increasingly younger people and children [6]. With the development of the possibility of health control over the patient, the demand for the implementation of remotely monitored rehabilitation has increased. An analysis was carried out to show the difference between rehabilitation carried out in a hospital and rehabilitation carried out at a patient's home. In one of the studies, 2 groups of patients were randomly selected, the first of whom carried out a rehabilitation program in a hospital, and the second - at home, under the supervision of a doctor over the phone. The study lasted 12 weeks, during which both groups performed exercises on the cycloergometer for 3 days a week. After the rehabilitation cycle was completed, the patients were examined and it was shown that both groups experienced a significant and comparable improvement in cardiovascular capacity. The analysis of the obtained results allows the conclusion that the effectiveness of home rehabilitation is not inferior to hospital rehabilitation [8]. Many studies point to the savings resulting from the introduction of a telemetry system to control and modify the cardiological rehabilitation process in the patient's home. At Hammon Heart Institute in Springfield, savings from this system calculated for the 36-week rehabilitation program amounted to USD 1,200 per patient [9]. Such economic results should provoke reflection on the validity of introducing such systems to public care. In Poland, similar cardiological rehabilitation programs for their patients have been implemented by the Institute of Cardiology in Anin, where patients have at their disposal a modern Telecardiology Laboratory, which enables 24-hour monitoring of patients' hearts. Orthopedics and traumatology also offer a wide field of application of telerehabilitation.

The innovative research project CLEAR was also implemented. Apart from Poland, it is carried out simultaneously in 3 other member states of the European Union: Spain, Italy and the Netherlands. The project is aimed at patients with degenerative changes after knee and hip joint endoprostheses. Its task is to assess the effectiveness and applicability of telerehabilitation at home, to introduce protocols for home rehabilitation and support for home care activating the patient, and for the first time on a European scale - to agree on the standards of home telerehabilitation via the Internet.

The implementation of the objectives of the project are introduced by the Department and Clinic of Orthopedics and Traumatology of the Locomotor System, Center of Excellence "TeleOrto" of the Medical University of Warsaw [10]. Previous studies published in the Journal of Bone and Joint Surgery show no significant differences between the results of home and hospital rehabilitation [11]. Currently, an increasing and still underestimated problem is sensorineural deafness in people over 50, the so-called senile deafness.

It is estimated that for the population between 65 and 75 years of age, the percentage of people with senile deafness oscillates between 6 and 10% [12]. A certain group of these patients has a chance to qualify for cochlear implantation. Although this procedure is associated mainly with the treatment of young children, with the indication of those who are deaf from birth, cochlear implantation also gives a chance to restore the hearing ability in the seniors group [13]. The cochlear implantation procedure is followed by long-term rehabilitation and the need to remain under constant medical supervision. According to the procedure, the patient must undergo a series of visits (3-12 / year) conducted by an experienced, multidisciplinary team at the facility implanting the implant. A telemedicine system was created that enables cheap and effective rehabilitation of hearing and speech (telerehabilitation) and remote service of patients using cochlear implants (tele-fitting). In the project implemented by the Institute of Physiology and Pathology of Hearing in Kajetany, consultations take place via a link integrated with a system that remotely adjusts the cochlear implant to the patient's current needs. Over time, the system was supplemented with new elements (including tele-education, screening tests, telediagnosics). This is how the first National Teleaudiology Network in the world was created [14].
Thanks to the rapid progress in the field of computerization and the use of new technologies in medicine, it is possible to carry out tests in the field of ECG, EMG, EEG, sensors for measuring blood pressure, sensors for measuring the degree of blood saturation, such as the pulse oximeter used recently in the Covid-19 era, a sensor for breathing monitoring, to assess the patient's activity, or a "smart sock" sensor or a shoe insole equipped with a sensor for assessing and determining the phases of individual steps used among children in the case of postural defects development and among adult patients, e.g., after a stroke [10].

**Telepulmonology**

In the era of a pandemic, pulmonary patients constitute a growing multi-age group that is subject to remote monitoring. In this case, it is necessary to regularly control vital signs, supervise the intake of medications and the use of apparatus. Diagnostics can take a long time, and treatment must be individually adjusted.

The integrated measuring devices include: peak flow meter, spirometer and pulse oximeter. Patients, supported by the application, perform a series of tests, and the results are automatically sent to the Comarch e-Care platform. More than 600 patients with chronic obstructive pulmonary disease, after Covid-19, amyotrophic lateral sclerosis or cystic fibrosis benefit from remote monitoring. The results show that both their quality of life and mental well-being are improving. The MedicAir Group is a leader in home oxygen therapy and pulmonary ventilators in Italy. For over 30 years, it has been providing assistance to over 70,000 patients, and since 2014 also telemedicine services. Thanks to the modern technology used by the patient at home, it allows to quickly detect the exacerbation of the patient's condition, which allows to modify the pharmacological treatment without visiting a doctor, reduces the need for and shortens the patient's hospitalization time and optimizes the costs of care [10].
The European Institute of Regional Development Association, one of the project partners, launched the Telecare Center in Sucha Beskidzka. Qualified staff 24/7 monitors the condition of program participants, responds to calls and provides information on benefits ensured. Thanks to the use of innovative telecare solutions, fast, professional assistance has been provided to people most vulnerable to health and life threat. The Comarch company provided the equipment, hardware and software to the Telecare Center. Taking into account the development and commitment to organizing modern medical care, it is worth paying attention to other possibilities and proposals that the elderly or chronically ill people have to use [17].

**Comarch telemedicine cloud**

Comarch Telemedicine Cloud is an open cloud platform that enables remote monitoring of patients. Information from systems, applications and measuring devices goes to the Comarch e-Care platform, where it is analyzed and available to medical personnel. As a result, the process of diagnosis, treatment and prevention is optimized and coordinated, and some services are transferred outside of medical facilities. Comarch Telemedicine Cloud is a flexible and scalable solution that allows for the modification of existing elements and the addition of new devices, procedures and diagrams. Comarch Healthcare offers an extensive ecosystem of health solutions, which consists of EHR Cloud, Telemedicine Cloud, Hospital Cloud and Medical AI Cloud. The integration of these platforms helps to ensure coordinated healthcare and supports patients, carers and healthcare professionals. The basis of Telemedicine Cloud is the Comarch e-Care platform, which receives and processes medical data of patients. For their analysis, implemented learning algorithms (AI) are used, which immediately indicate irregularities, even in a large amount of information. The Comarch e-Care platform also enables on-line consultations and remote description of test results, which significantly increases access to high-quality medical services [17].

**Conclusions**

Telemedicine and its rapid development are undeniably an alternative way of quick contact between the patient and the doctor. It allows for up-to-date and complete collection of information on the health condition of patients with various chronic diseases. In addition, it increases the involvement of patients in the treatment process. The wide introduction of telemedicine systems intensifies the positive results of treatment, and also relieves stationary medical facilities. It also gives the possibility of quick intervention in case of the occurrence of any disturbing changes, the possibility of coordinated care and saving time of staff and patients. These systems are tailored to the individual needs of patients. Undoubtedly, they significantly reduce the cost of care and increase the availability of services.

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10. Innovative telemedicine applications and e-health services in the care of older patients

Maria Magdalena Bujnowska-Fedak, Mikołaj Tomczak Katedra i Zakład Medycyny Rodzinnej, Uniwersytet Medyczny, Wrocław

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