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# NEW TECHNOLOGIES IN MEDICINE

## Nowe technologie w medycynie

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A - Koncepcja i projekt badania, B - Gromadzenie i/lub zestawianie danych, C - Analiza i interpretacja danych, D - Napisanie artykułu, E - Krytyczne zrecenzowanie artykułu, F - Zatwierdzenie ostatecznej wersji artykułu

**Abstract (in Polish):**
Rozwój nowych technologii daje możliwość tworzenia innowacyjnych metod, których zastosowanie w medycynie może okazać się przełomem. Techniki te mogą być stosowane na wielu poziomach procesu diagnostyczno-terapeutycznego, począwszy od zbierania wywiadu, a skończywszy na leczeniu domowym pacjenta. W ostatnim czasie coraz bardziej powszechne staje się wykorzystywanie narzędzi telekomunikacyjnych łączących wiele technologii cyfrowych. Telemedycyna rozwinęła się znacząco w czasie pandemii COVID-19, kiedy liczba kontaktowych wizyt lekarskich była ograniczona ze względu na zagrożenie epidemiologiczne. Nowe technologie to jednak nie tylko komunikacja cyfrowa. Sztuczna inteligencja jest coraz częściej wykorzystywana w medycynie w celu ułatwienia procesu diagnostycznego.

**Abstract (in English):**
The development of new technologies gives the opportunity to create innovative methods, the application of which in medicine may turn out to be a breakthrough. These techniques can be used at many levels

of the diagnostic and therapeutic process, ranging from interview collecting and ending with home treatment of the patient. Recently, it has become more and more common to use telecommunications tools combining many digital technologies. Telemedicine developed significantly during the COVID-19 pandemic, when the number of contact medical visits was limited due to the epidemiological threat. New technologies, however, are not only digital communication. Artificial intelligence is increasingly used in medicine to facilitate the diagnostic process. The applied algorithms make it possible to detect defects at the stage imperceptible with the use of conventional methods.

**Keywords (in Polish):** nowe technologie, sztuczna inteligencja, metody diagnostyczne.

**Keywords (in English):** New technologies, artificial intelligence, diagnostic methods.

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## Introduction

In the last twenty years there has been a huge breakthrough in new technologies. Many portable devices have been created, which today are used not only for communication. Computers, smartphones, tablets and various types of accessories are tools for work and entertainment. They have also found their application in medicine, which was particularly significant during the COVID-19 pandemic. The aim of the work is to review the use of new technologies in various fields of medicine.

## Overview

### 1. Digitalization of patient care

The development of new technologies at the turn of the last few years has contributed to the digitization of healthcare. This phenomenon is based on many pillars - the patient, devices or medical entities. Access to the latest networks, especially broadband, streamlines this process and makes it extremely smooth. The use of digital devices is changing the methods of providing healthcare to remote. This is a great convenience for both health care personnel and, above all, for the patient. The accuracy and technical capabilities of mobile devices should be continuously validated. In addition, algorithms should

be constructed in such a way as to extract only the quintessence from the received data. These techniques can be used at many levels of the diagnostic and therapeutic process, starting from the history taking [1]

Digital devices play a vital role in patient care and chronic disease monitoring. They allow not only to monitor the patient's health, but also to better understand the course and pathophysiology of civilization diseases, such as diabetes or hypertension. An important element is also good data transfer, which allows individual monitoring elements to connect. Digital devices used in medicine include sensors, wireless devices, portable imaging devices - used e.g. in ultrasound. However, it should be mentioned that a smartphone turns out to be an extremely useful piece of equipment in the era of today's technology - it is both a monitoring device and enables the collection and processing of data obtained by sensors placed on the body [2,3]

Modern adapters and their software enable real-time control of patient parameters. An example is ECG electrodes connected to a smartphone. Thanks to the attached application, they enable saving the electrocardiogram in PDF format and sending it to the server of the medical entity for verification by the doctor. In addition, the artificial intelligence has been equipped with algorithms for detecting the most common, life-threatening abnormalities, i.e. atrial fibrillation [4]. In a manner analogous to devices connected to a smartphone, technologies aimed at monitoring glucose or blood pressure were developed. Blood pressure measuring devices are like watches. They use applanation tonometry. In addition, smartwatches have become more and more common, most of which have the function of measuring heart rate, saturation or CTK. Higher-class equipment also has the ability to perform an ECG and measure body fat [5].

Continuous glucose monitoring (CGM) uses minimally invasive sensors. It involves the implantation of a small percutaneous electrode into the subcutaneous tissue of the abdomen or upper arm, where the chemical reaction of the oxidase makes it possible to determine the electrical signal reflecting the concentration of glucose. This signal is converted to glucose concentrations and sent to your smartphone or tablet at 5-minute intervals for real-time continuous monitoring [6]. Several aspects of CGM have been shown to be effective in patients with diabetes, including the prevention of hypoglycemic episodes with early detection, and as a method of long-term glycemic control resulting from positive behavioral changes such as diet, exercise, and medication use made easier by awareness of glucose measurements and trends in real time [4]

## 2. Telemedicine and artificial intelligence in ophthalmology

Conventional diagnostic methods for ophthalmic diseases are based on clinical judgment and, increasingly, on the use of imaging techniques in various modalities. This process is time consuming and expensive, but also makes ophthalmology one of the specialties where the latest technologies can be of particular importance. Application to ophthalmic images such as digital fundus and visual field studies has been reported to achieve automated screening and diagnosis of common vision-threatening diseases including diabetic retinopathy, glaucoma, retinopathy of prematurity [4]. In these diseases, the development of technology and the use of newer and newer algorithms can be a valuable addition to diagnostic processes. There is also a chance to use them as an alternative to existing solutions. It will also be possible to introduce innovative screening programs that will allow the detection of diseases at an early stage. Solutions of this type will enable the introduction of treatment in the initial stages of the disease, and thus increase the chances of returning to a physiological state [8]. Augmented reality (AR), where real-time computer-aided information is generated and graphically supplemented on a display, could also have wide implications for healthcare. AR integrates virtual objects with real-world space, while

VR (virtual reality) typically blocks information from the real environment and transports users into a virtual simulated world. VR devices are used to treat patients with visual impairments. However, this technology limits peripheral vision, as well as due to the way of use - the use of goggles and headphones that limit the arrival of stimuli from the real world - carries the risk of falls and related injuries [10]. For this reason, the advantage of AR over VR is perceived. Recently, augmented reality technology has also found its application in ophthalmic surgery, replacing the traditional operating microscope [11]. Digital innovations have found their application in many eye diseases (Fig. 1.).

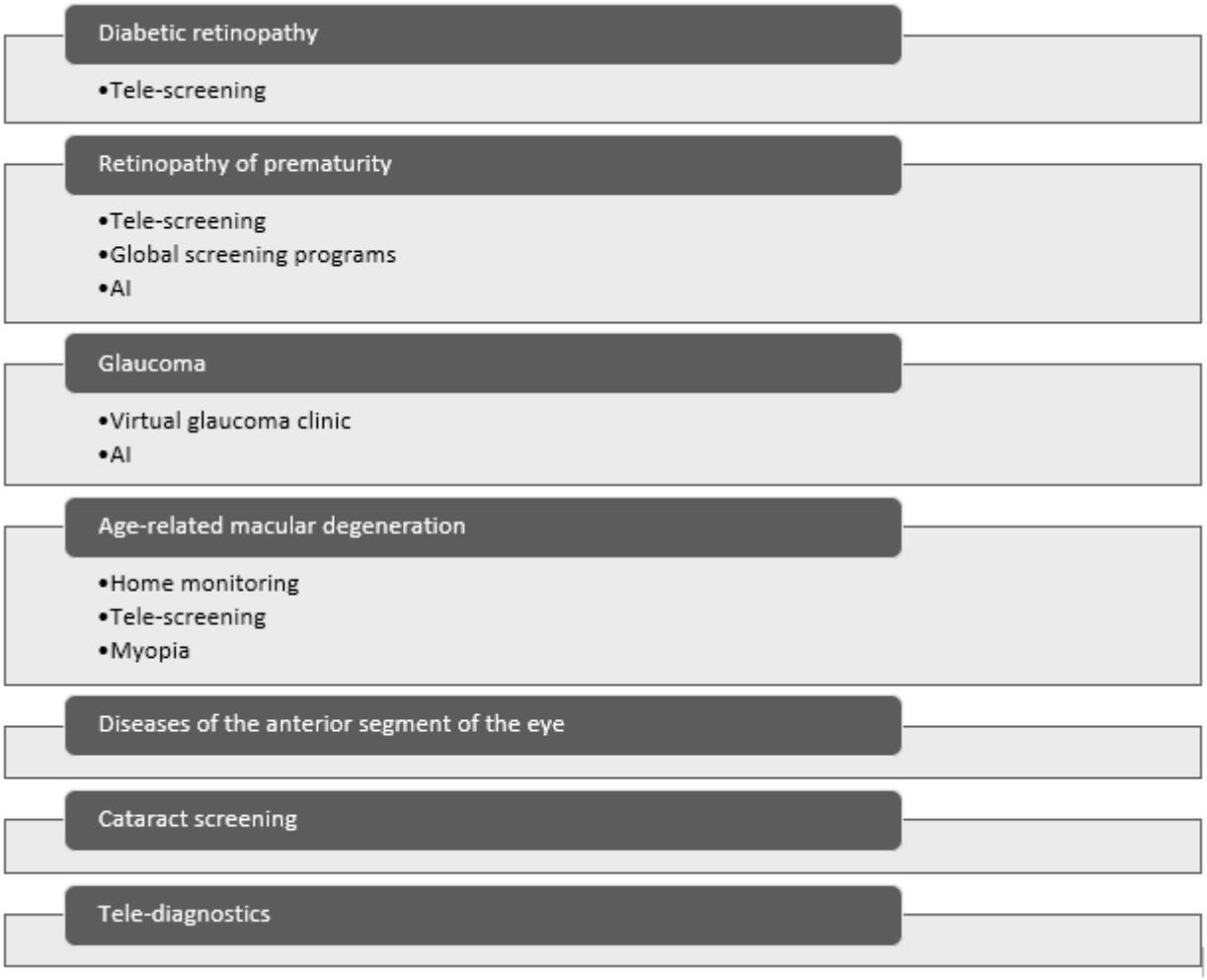


**Fig. 1. Application of digital technologies in ophthalmic diseases**

Despite the intensive development of digital technologies, automation and their use are still underestimated in the medical industry. The main concern is the risk that suboptimal implementation of digital technology may result in harm to the patient. It should be noted, however, that research into the use of new technologies can facilitate and accelerate the diagnostic and therapeutic process. A key element in the implementation of this innovation should be the establishment of appropriate health care standards [12].

## 3. New technologies in gynecology and obstetrics

Gynecology and obstetrics are fields of medicine that are the quintessence of almost all medical specialties. In addition to typical gynecology diseases related to the female reproductive system, this

specialty also includes issues in internal medicine, endocrinology and elements of surgery. In addition, obstetrics has its own specificity, which consists in taking care not only of the patient, but also of her child. The complexity of this field gives the opportunity to use new technologies to a large extent [13].

AI in gynecological cancers

In recent decades, more and more scientists have used advanced technology to predict various diseases. This also applies to gynecological cancers. Ultrasonography is the first-line examination used in the diagnosis of these diseases. Its main disadvantage is the subjectivity of the examination, which consists of the class of equipment or the doctor's experience. The use of neural networks is an answer to this problem. A study by Aramendía-Vidaurreta et al. shows that the accuracy of automatic identification of malignant adnexal tumors is close to 99%. The examination algorithm was based on the patient's age and ultrasound characteristics (e.g. entropy, fractal dimension, Gabor method) [14]. The prognosis of gynecological cancer is currently based on the FIGO classification. The modern shift towards new radiological or molecular biomarkers is the next step in stratifying treatment. The use of artificial intelligence has an advantage over the examination performed by less experienced sonographers. The implementation of this solution, due to the lack of input from a specialist, is of key importance for making decisions related to the extension of diagnostics or referral for specialist treatment in primary health care. It also provides an opportunity to improve the screening program [15].

Endometrial cancer is the most common gynecologic malignancy and has clinical and pathological features, such as pelvic and para-aortic node metastases, that reduce women's survival. Accurate clinical staging of endometrial cancer will assist in effectively staging patients for the best surgical and/or adjuvant treatment. Texture features assessed by magnetic resonance imaging are used to assess the prognosis in endometrial cancer. MRI combined with AI can discriminate clinicopathological prognoses before treatment, thus providing clinical benefit to patients. Scientific research shows that the diagnostic accuracy of artificial intelligence is comparable to that achieved by radiologists. It is believed, that AI could help radiologists or serve as a reasonable alternative for pre-operative assessment of the depth of myometrial invasion in stage I endometrial cancer. However, this study also found that AI was more likely to misinterpret patients with coexisting benign leiomyomas or polypoid tumors [16].

The screening program for early detection of gynecological cancers is based on cytology. In most countries, cytology has been used as the primary screening method since the 1950s. The Pap smear was first analyzed using the Papanicolaou test, but is now evaluated according to the Bethesda system. Liquid-based cytology (LBC) is another screening test [17]. However, this method has some limitations, is time-consuming and, like ultrasound, is subjective. Numerous research teams are trying to develop a system to help detect abnormalities and obtain more accurate results. Most researchers propose classification methods based on neural networks. They make it possible to isolate individual elements of the image and assign the examined material to the appropriate category. This method is highly effective both in the case of smears and liquid cytology [18].

The problem of gynecological cancers is not only based on the diagnosis of these diseases. The treatment process is also a big challenge. Due to individual differences in cancer patients and the emergence of multi-drug resistance, many patients have poor drug sensitivity, resulting in unsatisfactory therapeutic results. Artificial intelligence is helpful in guiding activities aimed at meeting this challenge. The use of its elements allows you to predict the effects of treatment using a given method. The algorithms are based not only on the size of the tumor or clinical stage, but also on the subjective examination of the patient. This is to select the most optimal solution for the patient, which is in line with the assumptions of personalized medicine [19].

New technologies in reproductive medicine

Rapid technological progress, as well as the related increase in the amount of data necessary to process it, has exceeded the capabilities of conventional statistical methods. By analyzing medical data, artificial intelligence is getting better and better at detecting potential relationships that may indicate abnormalities or the need for medical intervention. It has also found its application in reproductive medicine. It is a helpful tool for experts aimed at selecting the most optimal method of infertility treatment, increasing the percentage of pregnancies and reducing the financial burden. The quality of the embryos is the most important factor in the success of IVF, but methods for accurately assessing the quality of eggs, sperm and embryos are still lacking. It is difficult to predict the probability of a successful pregnancy and to fully understand the reason for failures.[20] Reproductive success is greatly influenced by the quality of the oocytes. Due to the fact that despite normal morphology, the oocyte may show aneuploidy, it is necessary to understand the mechanisms underlying these abnormalities and develop a diagnostic algorithm. Such an attempt was made by Cavalera et al. The research team observed mouse oocytes during their maturation from the embryonic vesicle to metaphase II and took photos for time-lapse analysis. They calculated the cytoplasmic movement velocity profile and then analyzed the data using an artificial neural network to identify competent or incompetent oocytes. The accuracy of this method was over 90% [21].

Semen analysis is the first step in the diagnosis of infertility. Sperm morphology reflects the types of abnormalities in semen samples. This test is crucial for fertility. Today, computer-assisted semen analysis systems are used for research and routine analysis in humans or animals. The system can report motility percentage and kinematic parameters and identify sperm subpopulations [22]. Due to the inherent lack of objectivity and difficulty in assessing sperm morphology manually, and the high degree of inter-laboratory variability, automated image-based methods need to be developed to obtain more objective and precise results. One third of male factor infertility is idiopathic, which means that semen analysis methods cannot detect many causes of infertility. The use of artificial intelligence gives an opportunity to discover relationships invisible to humans and to develop reproductive medicine [23]. Precise assessment of embryo viability is a major factor in the success of IVF treatment. In most cases, embryologists select embryos through a visual examination. Evaluation of embryos is therefore subjective, which may translate into the ultimate success rate. Therefore, the introduction of automatic morphological analysis of embryos and blastocysts using AI seems to be an attractive solution [24]. Many couples who are being treated for infertility are considering in vitro fertilization. The main barrier remains the high cost of IVF with low pregnancy rates. The use of forecasting models based on artificial intelligence gives the opportunity to personalize the selected methods and improve treatment results. The literature shows that the accuracy of forecasting varies between 59 and 84.4%. Therefore, this method requires continuous development in order to achieve higher efficiency rates [25].

Artificial intelligence in obstetric monitoring

Optimizing the accuracy of fetal examinations is another area where AI can have direct clinical relevance. Machine learning capabilities will enable the creation of personalized algorithms and AI-based software with interactive visualization and automated quantification. This is to speed up clinical decision-making and reduce analysis time. A particularly important role of artificial intelligence is seen in fetal echocardiography and in the diagnosis of the central nervous system. The introduction of 3D/4D technology has made it possible to expand display options, which are increasingly used for automatic image analysis. Some manufacturers offer tools to facilitate echocardiographic imaging and its interpretation. This technology also gives the opportunity to accurately assess the anatomy of the heart

and other organs important for the fetus and to detect potential defects already at the prenatal stage. This makes it possible to plan the therapeutic process before the child is born and to prepare parents to care for a sick child. The undoubted advantage of technologies based on artificial intelligence is to help less experienced practitioners identify highly complex anatomical structures in a standardized and objective way.

## 4. Summary

As AI systems continue to be developed and integrated into clinical processes, there are huge expectations about what their impact will be on healthcare. The use of these tools may be essential in modernizing the training models of future physicians. The development of technology will also change the treatment models for many diseases. It will have a significant impact on the functioning of the health care system. However, it should be remembered that the tasks performed by automated elements must be constantly monitored by qualified medical personnel. In addition, there are barriers that AI cannot overcome – tasks that require emotional intelligence, such as bonding, building trust, or spotting signs or symptoms that require empathy

## Conclusions

1. The COVID-19 pandemic has undoubtedly influenced the development of telemedicine and the digitization of healthcare. It reduced the number of contact doctor visits and also contributed to the popularization of solutions such as ePrescription or eReferral.
2. New technologies, i.e. artificial intelligence or augmented reality, give the opportunity to develop diagnostic methods and screening tests. This will make it possible to introduce treatment at an early stage of the disease and increase the chances of survival for patients.
3. Many fields of medicine are increasingly using artificial intelligence. However, it is not possible to fully automate patient care. Activities carried out by AI must be regularly controlled by qualified personnel.

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