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THE ROLE AND EFFICIENCY OF INFORMATION TECHNOLOGIES IN EARLY DETECTION OF UROLOGICAL DISEASES

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Abstract: This article analyzes the role of modern information technologies in the early detection of urological diseases and their effectiveness. The possibilities of automating and effectively organizing urological diagnostic processes through information systems, artificial intelligence, telemedicine and data analysis tools are considered. Also, the possibilities of increasing the effectiveness of treatment through early detection of diseases, preventing disease exacerbations and rational use of medical resources are analyzed. The article proves the importance of information technologies based on the results of scientific research and examples used in practice.
Keywords: Diagnostic technologies, machine learning, telemedicine, data analysis, interactive monitoring.

Introduction. The integration of information technology (IT) into the healthcare system is revolutionizing the early detection and monitoring of urological diseases.

According to the World Health Organization (WHO), prostate cancer is diagnosed in more than 1.4 million men worldwide each year, and this disease is one of the leading causes of death among men. Therefore, early diagnosis is crucial to improve prognosis and treatment outcomes. Diagnostic algorithms based on machine learning (ML) and deep artificial intelligence (AI) are significantly increasing the level of accuracy by analyzing medical images, biomarkers, and clinical data. For example, it has been noted that systems that automatically analyze prostate biopsy samples sometimes perform better than 10 pathologists. In addition, an AI-based urine biomarker analysis platform developed by a Korean scientist has been shown to detect prostate cancer with 99% accuracy. Telemedicine allows patients to quickly and conveniently address a variety of urological problems remotely, including urinary tract infections, sexual dysfunction, prostate diseases, and pelvic examinations. For example, the use of teleurology has tripled during the pandemic, with 80% of patients indicating a desire to use it in the future. In addition, according to data from one center in the United States, teleurology services saved patients an average of $152 in travel costs and reduced 153 tons of CO_2. It also allows for real-time monitoring of patients, analysis of symptom dynamics, detection of exacerbations, and planning of routine medical interventions with the help of comprehensive data analytics (bigdata analytics) and

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interactive monitoring tools. Archive articles have highlighted the effectiveness of such technologies in chronic or regimen-based monitoring, which can prevent adverse clinical events.

In this article:

The role of IT in the diagnostic process and the accuracy of disease detection using ML and AI algorithms will be analyzed;

The benefits of telemedicine for patients — such as accessibility and cost savings — will be examined with evidence;

The role of interactive monitoring and big data approaches in preventing the progression of the disease is demonstrated.

Based on these analyses, the article proves the role of information technologies as an innovative, effective solution for early diagnosis and monitoring in the field of urology. Its significant contribution to optimizing treatment strategies, rational use of medical resources, and improving patient health is emphasized.

Urological diseases are a complex of diseases associated with the urinary system (kidneys, bladder, urethra) and male genital organs. Below is a brief description of urological diseases and their main types:

- Main urological diseases:
- Urinary tract infections (UTIs) - most often caused by bacteria, more common in women.
- Kidney stones - formed as a result of the accumulation of crystals in the urine.
- Prostate diseases - prostate adenoma, prostatitis, prostate cancer.
- Urinary incontinence - occurs especially in older people.
- Renal failure - a condition in which the kidneys fail to function properly.

Diagnostic methods:

- Laboratory tests (urine and blood)
- Ultrasound (ultrasound)
- CT (computed tomography)
- MRI (magnetic resonance imaging)

Cystoscopy

- Role of information technology:
- Electronic storage of medical data
- Rapid diagnostic systems (AI-based)
- Remote consultation and telemedicine
- Symptom monitoring via mobile applications

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Early diagnosis is the process of detecting a disease in its early stages, which serves to increase the effectiveness of treatment, prevent complications, and improve the quality and duration of the patient's life.

The main advantages of early diagnosis include:

1. The possibility of early treatment of the disease

2. Reducing the cost of treatment

3. Prevention of complications

4. Timely implementation of preventive measures

5. Improving the patient's quality of life

Early diagnostic methods: Screening (popular medical examinations), Genetic tests and biomarker detection, Analysis using artificial intelligence, Hardware methods such as ultrasound, X-ray, CT, MRI, Monitoring through mobile health applications

Early diagnosis is especially important in diseases that are often latent and worsen over time, such as urological diseases.

This scientific article conducted a systematic review of the use of information technology (IT) in the early detection of urological diseases. First, articles published between 2015 and 2024 from major scientific databases such as PubMed, ScienceDirect, Springer, IEEE Xplore, and GoogleScholar were selected. These articles studied the effectiveness of artificial intelligence (AI), machine learning (ML), telemedicine, medical image analysis, and interactive monitoring tools in urological diagnostics. The selection of articles was carried out based on the PRISMA protocol. The research analyzed the results of machine learning algorithms widely used in the development of diagnostic models, in particular, Support VectorMachine (SVM), RandomForest (RF), LogisticRegression (LR) and DeepLearning (deep neural networks). These models were used in classification, segmentation and prediction tasks in cases related to prostate cancer, bladder tumors and kidney diseases. For example, a meta-analytic analysis published in 2023 reported 94–98% accuracy, 91% sensitivity and 89% specificity in the analysis of prostate biopsy using artificial intelligence (Lee et al., 2023). Also, systems for early detection of prostate and kidney diseases using MRI and CT images using convolutional neural networks (CNN) based on computer vision were studied. Using radiomics technology, features extracted from images were evaluated with special algorithms and the possibility of drawing clinical conclusions using them was considered (Gillies et al., 2020).

To test these technologies in real-world settings, the results of remote diagnostics and interactive monitoring systems via telemedicine services have also been studied. In a 2021 study at a US clinic, patients saved an average of $152 in travel costs through teleurological consultations, while also reducing carbon dioxide emissions (Lourenco et al., 2021).

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In addition, using interactive monitoring devices, data such as patients' urination rate, bladder movement, and pain level were collected in real time and analyzed by algorithms. This served to speed up medical interventions (Kim et al., 2022). During the study, the following indicators were used in model evaluation: AUC (AreaUnderCurve), accuracy, sensitivity, and specificity. In cases of prostate cancer, the AUC value of DL models was in the range of 0.90–0.97. In particular, special algorithms such as UDORA (Urodynamics Overactivity Recognition Algorithm) and DUMA (DetrusorUnderactivity Model Algorithm) showed high results in the field of urodynamic analysis: UDORA AUC was 91.9%, and DUMA gave effective treatment recommendations in 82% (Chen et al., 2022). The methods considered in the article have become core components of medical information systems, allowing not only to automate diagnostic processes, but also to provide a personalized approach to disease detection and treatment.

Thus, based on this methodology, ways were identified for the early detection of urological diseases using information technologies, rational use of resources, and improvement of the patient's condition.

The analysis showed that modern information technologies, especially artificial intelligence (AI), machine learning (ML), telemedicine and interactive monitoring tools, play an important role in the early detection and effective treatment of urological diseases. AI-based algorithms, including convolutional neural networks (CNN), Random Forest, XGBoost and other models, have shown high accuracy and sensitivity compared to traditional diagnostic methods in detecting prostate cancer, bladder tumors and kidney-related pathologies.

For example, in a study conducted at UCLA, an AI-based model detected prostate cancer with an accuracy of 84%, compared to 67% for doctors (Lee et al., 2023). In biopsy analysis models developed based on deep learning, the AUC (AreaUndertheCurve) value reached 0.997, which is a very high result in the field of pathological diagnosis (Bulten et al., 2020). At the same time, algorithms developed based on machine learning increased the diagnostic AUC to 0.93 for patients with PSA < 20 ng/ml (Shah et al., 2022). Models based on imaging modalities such as MRI, mpMRI, and TRUS also showed high performance. In a multicenter study, the sensitivity and specificity of analyzing prostate MRI images using artificial intelligence were 80% and 88%, respectively (Nagpal et al., 2019). A bladder tumor detection model developed on Google Net was trained on 2,104 cystoscopy images and showed 89.7% sensitivity and 94.0% specificity (Zheng et al., 2021). Positive results have also been reported in the field of telemedicine. In a study conducted in the United States with 400 patients, patients saved an average of $124 in travel and service costs through tele-urology consultations (Lourenco et al., 2021). In addition, remote monitoring and consultations through telemedicine reduced carbon dioxide (CO_2) emissions by up to 153 tons, which also brought environmental benefits (Hollander & Carr, 2020). Real-time monitoring of patients' condition using interactive monitoring tools, artificial intelligence assessment of urinary flow rate, pain level, and other physiological parameters, allowed doctors to make rapid clinical decisions. In particular, systems such as UDORA (UrodynamicsOveractivityRecognitionAlgorithm) and DUMA (DetrusorUnderactivity Model Algorithm) have shown AUC results of 91.9% and 82%, respectively, in detecting urodynamic problems (Chen et al., 2022). These results show that early detection of urological diseases using information technologies can not only increase clinical accuracy, but also improve the patient's quality of life, increase the effectiveness of treatment and

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reduce medical costs. At the same time, existing studies have some limitations: many models have been studied only in one center, have not been tested in real clinical conditions or are based on retrospective data. Therefore, for the widespread implementation of such systems, they need to be tested in multicenter, long-term and with the participation of different demographic groups. On this basis, it can be said that modern information technologies - artificial intelligence, machine learning, telemedicine and monitoring systems - play an important role not only in the early detection of urological diseases, but also in their management. In the future, there is an opportunity to further develop personalized medicine approaches based on these technologies.

Conclusion. The role of modern information technologies in the early detection of urological diseases is significantly increasing in medical practice. The conducted analysis shows that artificial intelligence (AI), machine learning (ML), image processing algorithms, interactive monitoring systems and telemedicine services are helping to implement urological diagnostics quickly, accurately and in a resource-saving manner. Based on the research, it was found that the diagnostic efficiency of AI models (AUC up to 0.93–0.997) is higher than that of traditional methods, which helps to save patients from unnecessary invasive procedures, biopsies and incorrect diagnoses. At the same time, remote monitoring and telemedicine platforms allow clinical services to overcome geographical boundaries, reduce travel and time costs for patients, and contribute to environmental sustainability. AI-powered predictive and analytical systems are enabling early disease prediction, personalized treatment strategies, and decision support for physicians. Therefore, information technology-based diagnostic approaches not only improve clinical efficiency but also enable more efficient use of healthcare resources. However, many of the existing technologies have not yet been fully tested in widespread practice, and multicenter, long-term studies are needed to assess their reliability and universality. It is also necessary to increase trust between doctors and patients, ensure the understandability of algorithms, and guarantee information security when implementing AI-based models. Modern information technologies are the basis for revolutionary changes in urological medicine, opening up unprecedented opportunities for early diagnosis, precise treatment, and optimization of the healthcare system.

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