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THE ROLE OF HIGHER MEDICAL EDUCATION INSTITUTIONS OF UKRAINE IN THE DEVELOPMENT OF EVIDENCE-BASED MEDICINE USING ARTIFICIAL INTELLIGENCE AND MODERN TECHNOLOGIES

Abstract. The quality of life of the population, which primarily depends on a sufficient level of public health and its continuous improvement, remains a central

objective of both the government and the healthcare system. At present, Ukraine's healthcare system is undergoing active reform.

In Ukraine, personnel training for the healthcare sector is currently conducted in higher medical and pharmaceutical educational institutions of accreditation levels I to IV. These include 64 medical colleges, 47 medical schools and their branches, 2 nursing institutes, 12 medical universities, 2 medical academies, 1 national pharmaceutical university, and 3 academies of postgraduate education.

Therefore, the first step in addressing the current challenges in the healthcare sector is to modernize the educational system, particularly within institutions of higher medical education. Considering the global level of digitalization in educational processes, the primary task is to implement modern teaching methods.Technological innovations, especially e-learning and artificial intelligence (AI), have created new opportunities for both educators and students, significantly transforming approaches to learning.

Contemporary European standards associate the quality of educational services with the integration of diverse forms and levels of simulation-based training, gamification, and multiple applications of AI in the educational process.

According to this sequence of development, the increasing incorporation of advanced technologies, particularly AI, in the academic environment of Ukraine's higher medical institutions shapes the professional profile of future specialists. This, in turn, enhances the effectiveness of evidence-based medicine. However, the use of AI in both education and evidence-based clinical practice presents a number of unresolved challenges, including ethical considerations, data standardization, and regulatory frameworks.

AI undoubtedly offers substantial and previously unexplored opportunities for implementation in medicine. Once current limitations are addressed, it is possible to anticipate profound changes not only in the principles of evidence-based medicine but also in the structure and functioning of the healthcare systems of Ukraine and other countries.

Keywords: higher medical education institutions, evidence-based medicine, development, artificial intelligence.

Statement of the Problem. The quality of life of the population, which is primarily determined by an adequate level of public health and its consistent improvement, remains a key responsibility of both the government and the healthcare system. The healthcare system of Ukraine is currently undergoing active reform [1].

The document Strategy for the Development of the Healthcare System until 2030 [2] clearly states that the primary objective is to ensure the provision of high-quality healthcare services that are both accessible and affordable, along with the rational use of effective and safe medications.

Although healthcare remains a strategic pillar of Ukraine's national socio-economic development, the sector continues to encounter substantial difficulties. These

challenges significantly limit the public's access to medical services that are comprehensive, affordable, and timely. Contributing factors include the prolonged impact of the COVID-19 pandemic, the imposition of martial law, persistent financial constraints, and the closure of medical facilities, particularly those serving rural populations. Furthermore, the healthcare system faces a shortage of qualified personnel as well as an overall deficiency in material and technical resources necessary for effective medical service delivery.

The preparation of healthcare professionals in Ukraine is currently undertaken through a multi-tiered system of higher medical and pharmaceutical education. This system spans all four accreditation levels and incorporates a broad range of institutions. These include medical colleges, affiliated medical schools, institutes for nursing education, medical universities, specialized medical academies, a national pharmaceutical university, and institutions dedicated to postgraduate training. Together, they form the backbone of the national framework for developing human resources in the healthcare sector.

Therefore, the first necessary step in overcoming the current challenges in the healthcare system is the modernization of education, particularly in institutions of higher medical education. Given the global trends in digitalizing educational processes, the primary objective is implementing modern teaching methodologies.

Analysis of Recent Research and Publications. Modern learning technologies, particularly artificial intelligence (AI), are increasingly utilized in Ukrainian education [3], including in the training of medical professionals.

Currently, there is a growing movement toward integrating AI and other advanced technologies into the educational processes of Ukrainian universities, including medical institutions. For instance, in February 2025, Vinnytsia Pirogov National Medical University organized an educational and methodological conference titled Modernization of Educational Programs for Training Higher Education Students in Accordance with the Trends in the Development of the Ukrainian and Global Labor Markets [4]. In March 2025, Kharkiv State Medical University hosted an international conference titled Topical Issues of Pedagogy of Higher Medical Education [5].

The Center for Ukrainian and European Scientific Cooperation, in collaboration with the National University "Odesa Law Academy" and the National University of Physical Education and Sports of Ukraine (Kyiv), conducts nationwide scientific and pedagogical advanced training programs. As part of these initiatives, collections of abstracts from scientific and methodological presentations have been published, including Artificial Intelligence in Higher Education: Risks and Prospects for Integration [6] and Integration of Artificial Intelligence into Education: Challenges and Opportunities [7].

Research on the implementation of AI in medicine and medical education is also being conducted by scholars at Pylyp Orlyk International Classical University (Mykolaiv) [8], the National University of Pharmacy (Kharkiv) [8], the State

University of Telecommunications (Kyiv) [8], Ivano-Frankivsk National Medical University [9], Uzhhorod National University [10], Zaporizhzhia State University of Medicine and Pharmacy [10], Bukovinian State Medical University [3], among others.

In other words, nearly all higher education institutions under the jurisdiction of the Ministry of Health not only recognize the significance and urgency of these developments but also actively implement diverse modern methods in their academic programs.

The clear recognition that the successful integration of AI into evidence-based medicine must begin with its incorporation into the curricula of higher medical education institutions further underscores the relevance of analyzing the role of modern technologies in education. This aligns with the broader agenda of modernizing evidence-based medical practice.

The purpose of the article. To determine the role of higher medical education institutions of Ukraine in the development of evidence-based medicine using modern technologies, in particular, artificial intelligence.

Summary of the main material. The Ukrainian healthcare sector is undergoing rapid transformation as a result of significant nationwide changes. Education represents the initial stage of these systemic reforms. For instance, in several frontline educational institutions, online learning has become the only viable alternative, which underscores the relevance of modern methodological approaches.

Current trends in medical education emphasize the harmonization of theoretical and practical components within the learning process. This specificity is reflected in the adoption of flexible instructional strategies, including a multi-level, advanced interpretation of traditional teaching enhanced by digital tools such as training modules, quest-based tasks, and other interactive formats.

Increasing attention is being paid to shaping the personality of the student as a future healthcare professional. To achieve this, diverse pedagogical approaches are applied to facilitate the acquisition of theoretical knowledge by higher education students and to support its effective application in clinical practice.

Modern technologies, especially e-learning and artificial intelligence (AI), have created new opportunities for educators and learners alike and have led to a fundamental shift in educational paradigms [11].

Today’s digitally native students are able to navigate online platforms with ease. They benefit from free access to educational materials, interactive simulations, video demonstrations of laboratory procedures, and tools for real-time self-assessment through automated testing systems and clinical case studies.

The availability of lecture and practical materials on digital platforms such as Moodle, Google Classroom, and Coursera significantly enhances the efficiency of the learning process.

Of course, an important role in this process is played by the availability and quality of e-textbooks and other teaching and learning materials, the effectiveness of

adaptive learning platforms, automated knowledge assessment systems, and virtual assistants. In view of the significant share of online learning, informal education is gaining importance. It is based on the conscious self-organization of learning, aimed at acquiring specialized competencies, and effectively complements formal education by developing personalized approaches to learning in general and fostering the ability and motivation to engage in lifelong learning.

Modern European standards associate the quality of educational services with the introduction of diverse types and levels of simulation training into the academic process. Various visual tools are used in this context, including simulator models, phantoms, devices with integrated software and 3D technologies, virtual phantoms developed for specific topics, video courses, and presentations that include input and output knowledge control. The advantage of these approaches lies in the effective assimilation of theoretical content in combination with hands-on practice of diagnostic and therapeutic techniques. Another important benefit is the ability to repeatedly perform procedures in a low-stress environment, without the presence of a patient.

Contemporary simulators enable the recreation of a wide range of clinical scenarios with varying degrees of complexity, many of which students may not experience during in-person hospital training. The most significant outcome of simulation-based learning is the acquisition of practical skills, which in turn promotes the development of clinical thinking through greater confidence and continuous self-improvement. A crucial aspect of this process is the integration of all levels of medical training, with particular emphasis on aligning interdisciplinary components.

Promising approaches involve the creation of simulation classrooms equipped with various mannequins that facilitate enhanced procedural training. With the support of built-in sensors and compatible software platforms, such as those based on Windows or Android, educators are able to assess the effectiveness of students' skill acquisition in real time.

Gamification also occupies a prominent place among modern educational technologies. Higher education students readily and actively engage with gamified tools. A transparent scoring and rating system for participation in lectures and laboratory classes is now being widely implemented. This process is supported by interactive quizzes such as Kahoot and Quizizz, as well as training through virtual services and simulation games available on platforms like Body Interact. However, several limiting factors remain. These include the need for hardware and software of a sufficient technical level, the alignment of curricula with gamified learning strategies, and the challenge of establishing valid criteria for the realistic assessment of practical skills [12].

The rapid advancement of artificial intelligence has led to its integration into the educational process in general and into the medical education system in particular. Its advantages and disadvantages are now well documented (see Fig. 1).

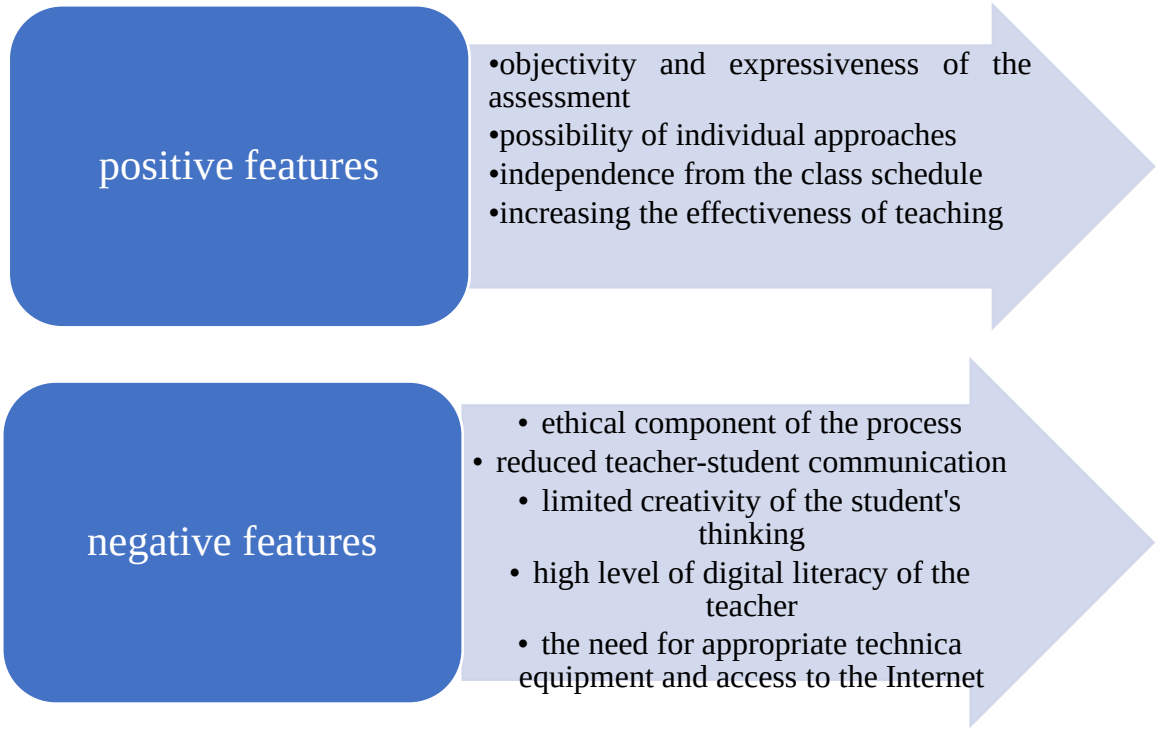

Fig. 1. Pro and con of using AI in education

The introduction of artificial intelligence (AI) has undoubtedly led to irreversible changes in teaching approaches worldwide. Alongside significant and valuable advantages, such as the reduction in time required to master theoretical and practical material and the increased personalization of the learning process, several drawbacks have also emerged [13].

Debates continue over the ethical implications and academic integrity associated with AI usage, and various approaches for its adaptive integration into the educational process have been proposed. However, both globally and within Ukraine, this integration requires substantial efforts to establish an appropriate regulatory framework. These challenges are expected to be addressed in the future.

Moreover, the systemic shift in teaching approaches has, in some cases, led to a reduction in students' autonomy in thought and action. This trend is driven in part by a diminished level of direct interaction between teachers and students, as well as by a declining emphasis on student independence. Given the high volume of self-directed learning, there is also a risk that students may pursue incorrect strategies or arrive at erroneous conclusions.

At present, there are several types of AI applications (see Fig. 2). For example, explanatory AI enables physicians to verify and interpret system-generated predictions. Clinical decision support systems help reduce diagnostic errors by guiding evidence-based decisions.

Quantum AI facilitates the rapid processing of data in real time through the use of quantum computing technology.

General AI possesses the potential to simulate human cognitive functions in the diagnostic process.

However, the use of AI is not without risks. Inaccurate or poorly labeled datasets can lead to false or misleading diagnoses. Other critical challenges include concerns about data confidentiality and the limited interoperability among different AI systems. These issues, along with unresolved ethical considerations, significantly complicate the integration of AI into healthcare system infrastructure [14].

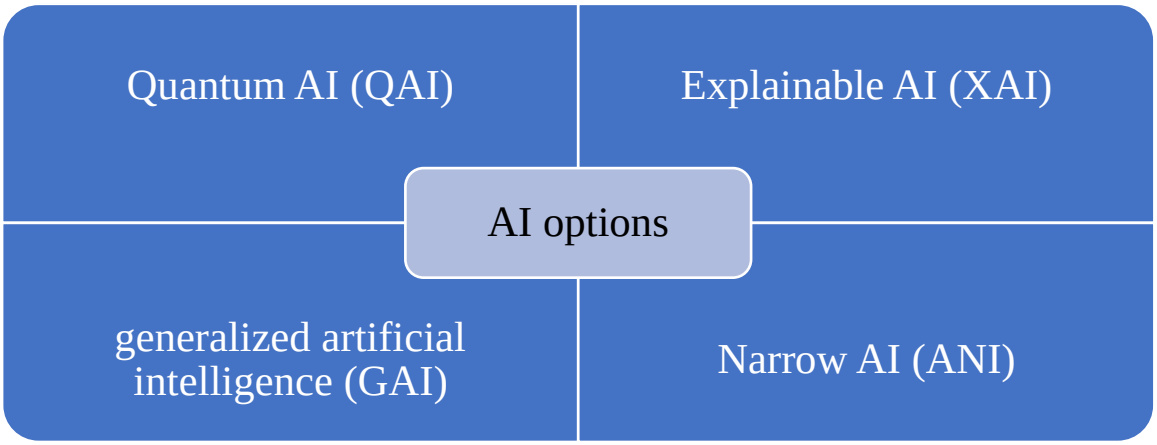

Fig. 2 Types of AI [15]

AI offers a significant advantage in evidence-based medicine by enhancing the ability to quickly and accurately diagnose a wide range of diseases. This advantage is largely due to its capacity to efficiently analyze large volumes of data (e.g., ECG, MRI, CT).

The broader integration of AI into the educational programs of medical institutions will support their modernization and should be considered a key factor in improving the quality of medical training. A critical aspect of contemporary medical education is the widespread use of simulators and various virtual tools, which are increasingly essential in the context of global uncertainty and numerous internal challenges.

The transformation of the educational process in higher medical education institutions demonstrates clear progress in the adoption of modern tools, including AI. However, several inhibiting factors persist. These include the need to improve the digital competencies of both faculty and students, as well as the necessity of expanding access to modern technologies, which often depends on funding levels.

Despite the competitive dynamics among higher education institutions, particularly in terms of student recruitment, we believe that the establishment of a unified state program titled “Innovations in Educational Components for Higher Medical Education Institutions” would significantly support the harmonization of national and regional efforts to develop students’ digital competencies and, ultimately, future physicians’ skills.

Most importantly, these efforts must contribute to the overarching goal of the healthcare system: safeguarding and improving the health of the Ukrainian population.

Specialized medical hubs, innovation centers, and regional clusters with well-defined positions on the application of modern technologies, including AI, in medical education and evidence-based medicine should be established throughout all regions of the country [16]. These initiatives can represent a significant step toward enhancing a sustainable and comprehensive digital infrastructure within the healthcare system.

Unfortunately, digital methods become ineffective in the absence of communication, electricity, or alternative power sources, which remains a frequent challenge under the current conditions in Ukraine.

Conclusions. The consistent implementation of modern technologies, particularly AI, in the educational process of domestic higher medical education institutions is shaping the professional profile of future specialists. This, in turn, contributes to increased effectiveness in the practice of evidence-based medicine.

AI holds significant and previously untapped potential for application in the medical field. However, the integration of AI into both education and evidence-based medicine presents several unresolved challenges. These include ethical considerations, data standardization, and regulatory issues. Once these current challenges are addressed, fundamental changes can be anticipated not only in the principles of evidence-based medicine but also in the broader healthcare system of Ukraine and other countries.

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