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EMERGING GLOBAL TRENDS AND INNOVATIONS IN MEDICAL EDUCATION: SHAPING THE FUTURE OF HEALTH CARE TRAINING

The development of medical education has been significantly influenced by advances in technology and AI, transforming how healthcare professionals are trained and improving the quality of education.

Ukraine has made notable progress in incorporating technology and AI into its medical education system, though challenges persist. These include limited infrastructure in some regions, financial constraints, and the need for broader access to advanced technologies. However, active involvement in international medical education networks, along with government support for digital education, offers promising prospects for expanding access to these innovations.

The integration of technology and AI in the medical curriculum is rapidly transforming how students access learning resources, develop practical skills, and engage with advanced diagnostic and treatment tools. This shift is helping prepare future healthcare professionals to work efficiently in a technology-driven medical environment. With continued investment in these technologies, the medical education system is on track to enhance both its sophistication and quality.

AI technologies also assist in personalizing education for students, offering tailored learning paths based on individual progress, performance, and areas that need improvement. This is particularly beneficial in large classes where individualized attention is limited. The integration of AI and digital technologies in the medical curriculum is preparing future healthcare professionals to work more efficiently and effectively in a technologically advanced medical landscape.

Despite the challenges posed by war and limited resources, Ukraine is making significant strides in adopting modern teaching methods and technologies. Ongoing reforms and international partnerships are likely to further strengthen the country's medical education system, helping to ensure that future healthcare professionals are well-prepared to meet evolving healthcare needs.

Keywords: *medical education system; integration of technology and AI; healthcare professionals; medical students; ongoing reforms.*

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СВІТОВІ НОВІТНІ ТРЕНДИ ТА ІННОВАЦІЇ В МЕДИЧНІЙ ОСВІТІ: МАЙБУТНЯ ПІДГОТОВКА В ГАЛУЗІ ОХОРОНИ ЗДОРОВ'Я

Розвиток медичної освіти зазнав значного впливу технологічних досягнень та штучного інтелекту (ШІ), що трансформують процес підготовки медичних працівників та підвищують якість освіти. Україна досягла значного прогресу в інтеграції технологій та ШІ в систему медичної освіти. Однак існують певні виклики, зокрема обмежена

інфраструктура в деяких регіонах, фінансові обмеження та потреба в розширенні доступу до передових технологій. Проте активна участь в міжнародних мережах медичної освіти та державна підтримка цифрової освіти відкривають перспективи для розширення доступу до цих інновацій.

Інтеграція технологій та ШІ в медичну програму навчання швидко змінює способи доступу студентів до навчальних ресурсів, розвитку практичних навичок та використання передових діагностичних і лікувальних інструментів. Це готує майбутніх медичних працівників до ефективної роботи в технологічно орієнтованому медичному середовищі. Продовжуючи інвестувати в ці технології, система медичної освіти має потенціал для підвищення своєї складності та якості.

ШІ також сприяє персоналізації освіти для студентів, пропонуючи індивідуальні навчальні шляхи на основі їхнього прогресу, результатів та областей, що потребують вдосконалення. Це особливо корисно в великих групах, де індивідуальна увага може бути обмеженою. Інтеграція ШІ та цифрових технологій у медичну навчальну програму готує майбутніх медичних працівників до більш ефективної та результативної роботи в технологічно розвинених медичних умовах.

Незважаючи на труднощі, пов'язані з війною та обмеженими ресурсами, Україна робить значні кроки в освоєнні сучасних методів навчання та технологій. Поточні реформи та міжнародні партнерства, ймовірно, ще більше зміцнять систему медичної освіти, забезпечуючи підготовку майбутніх медичних працівників до швидкоплинних потреб у системі охорони здоров'я.

Ключові слова: *система медичної освіти; інтеграція технологій та ШІ; медичні працівники; студенти-медики; поточні реформи.*

Introduction. In Ukraine, technology and AI have also played a significant role in revolutionizing medical education, transforming how healthcare professionals are trained and how medical institutions are adapting to the latest global trends. Technology is revolutionizing medical education by offering new avenues for engagement and interaction among students. It fosters enhanced collaboration, broadens professional networks, and facilitates the sharing of knowledge across diverse platforms. Furthermore, technology allows for a more personalized approach to learning, adapting to individual students' needs, preferences, and progress. Importantly, it also expands access to education, breaking down geographical and financial barriers, thereby democratizing learning opportunities and acting as an equalizer in the medical field.

Medical institutions have increasingly adopted online learning platforms, allowing students to access resources and lectures remotely. With the disruption caused by the COVID-19 pandemic, many universities transitioned to digital platforms such as Zoom, Moodle, and Google Classroom. These platforms support both synchronous and asynchronous learning, providing flexibility to students across the country, especially in rural and remote areas. Integrating e-learning into an existing curriculum necessitates a comprehensive and structured approach, beginning with a thorough needs assessment and analysis. This initial phase involves evaluating the specific educational gaps, technological requirements, and student learning preferences. Based on this analysis, the subsequent steps should be carefully designed to align e-learning strategies with the curriculum's goals and objectives. Ultimately, the process culminates in a well-informed decision regarding the adoption of e-learning, ensuring that its integration enhances educational outcomes and supports both teaching and learning processes effectively.

The **aim** of this article is to highlight the role of technology and AI in transforming medical education. It focuses on how medical institutions have adapted to digital learning platforms, particularly in response to the COVID-19 pandemic, and how these advancements have increased accessibility to education, especially for students in remote areas. Additionally, it emphasizes the global collaboration with e-learning platforms to offer specialized courses in medicine, broadening educational opportunities for students.

The **task** is the following:

– to inform about the integration of technology and AI in medical education system;

– to describe how digital platforms, accelerated by the COVID-19 pandemic, have enhanced access to learning resources for students, particularly in remote areas;

– to highlight how partnerships with global e-learning platforms are expanding opportunities for specialized medical education, ensuring that students can engage with international advancements in the field.

Literature review

Numerous scientists investigate medical education from different perspectives. Namely, Yang C., Jin X., Yan J. examine the intention and reasons of senior high school students in China to choose medical school; C. Del-Ben, V. Machado, M. Madisson study relationships between academic performance and affective changes during the first year at medical school; M.A.M. Siqueira, J. Gonçalves, V. Mendonça, define relationship between metacognitive awareness and motivation to learn in medical students; S. Budhathoki, P. Zwanikken, P. Pokharel, determine factors influencing medical students' motivation to practise in rural areas in low-income and middle-income countries; A. Wouters, G. Croiset, F. Galindo-Garre describe motivation of medical students: selection by motivation or motivation by selection; T. Mueller, U. Glowalla, consider teaching medicine with the help of "Dr. House"; J. Derck, K. Zahn, J. Finks study an innovative curriculum connecting underrepresented minority high school

students to medical school; M. Tominaga determines the structure of career choice among high school students: Relationships among career choice ability, career choice self-efficacy, and career choice behavior; R. Kusurkar, T.J. Ten Cate, Van Asperen M. define motivation as an independent and a dependent variable in medical education; I.C. McManus, G. Livingston, C. Katona study the attractions of medicine: the generic motivations of medical school applicants in relation to demography, personality and achievement.

Methods

A combination of research methods can be employed: literature review and data analytics will analyze global and research on digital platforms and AI in medical training; gather primary data and investigate successful medical schools using AI and digital platforms, while a comparative analysis will evaluate the progress against global trends; assess the impact of these technologies on student outcomes, and focus groups will provide qualitative insights into their effectiveness.

Discussion

In recent years, the government and medical universities have made efforts to modernize medical education and improve the quality of training or "refocus attention at all levels of training and instill fundamental, collaborative, open-minded behaviors so that future clinicians are primed to promote a culture of safer, higher-quality care" (Brian Wong, Wendy Levinson, Kaveh Shojania, 2012) namely:

– reforming curricula to incorporate more practical training, clinical skills, and patient interaction;

– establishing new partnerships with international medical schools for research collaboration and faculty exchange programs;

– increasing investment in digital tools and e-learning platforms;

– improving the quality of medical research and encouraging students to engage in scientific innovation.

The situation with medical education has been shaped by both significant challenges and remarkable progress, particularly in light of the ongoing conflict and the global shift towards digital learning. The ongoing war in Ukraine has posed serious challenges for medical education in the country, including disruptions in classes, destruction of infrastructure, and displacement of students and faculty. Many medical schools and universities in regions close to the conflict have had to suspend in-person classes or relocate to safer areas. Despite these challenges, medical schools have shown resilience by embracing online education, telemedicine, and remote learning to continue offering education to students. Some medical universities have shifted their focus to training students in emergency medicine and disaster response to meet the immediate needs of the healthcare system during the crisis or "to enhance their comprehension of varied motivations of students, especially in situations where career choices are made prematurely. Exploring specific interventions and support methods to alleviate external pressures, reduce the risk of burnout, and develop educational curricula that enhance students' long-term commitment to their careers remains an important challenge for future research" (A. Kikuchi, R. Kawamoto, M. Abe, D. Ninomiya, Y. Tokumoto & T. Kumagi 2025).

As we know medical education in Ukraine has embraced Virtual Reality (VR) and Augmented Reality (AR) technologies to offer immersive learning experiences and Mixed Reality Technologies revolutionizing and opening new world for the human senses. Virtual reality is being used for simulating surgeries, medical procedures and anatomy dissections. Some universities have incorporated these tools to help students learn complex procedures without the risks associated with hands-on practice on patients. They allow students to perform surgery simulations or explore 3D models of the human body, enhancing understanding and skills in a controlled, interactive environment. This is particularly important in the context of limited access to cadavers or medical equipment in some regions. It is also important "to move from the current manual management systems to a more digital-based system" according to scientists (Tuan D. Tran, Phuc M. Vu, Hong T.M. Pham, Luan N. Au, Hung P. Do, 2024).

As we know AI-Powered Learning Tools are being integrated into medical education in Ukraine through personalized learning tools. Some medical schools use AI-driven platforms to track student progress, assess weaknesses, and provide targeted recommendations for improvement. AI-powered tutoring systems analyze student performance offering real-time feedback to students and helping instructors tailor educational content to the needs of individual learners.

AI-driven diagnostic tools are being introduced into medical school curricula. These tools help students learn how to analyze medical images, such as X-rays, CT scans, and MRIs, with greater precision. AI can assist in detecting abnormalities and provide decision support, which is valuable in teaching medical students about the importance of accurate diagnosis and decision-making in detecting diseases like cancer, stroke, or heart conditions from medical imaging, helping them become familiar with how technology can enhance diagnostic capabilities suggesting "quality improvement" as commonplace in healthcare contexts and also used in some educational contexts (Susan Jamieson, 2022).

Furthermore, AI algorithms are being used in medical research and diagnostic education, teaching students how to interpret medical data more efficiently and accurately. AI-based software aids in teaching radiology, pathology, and surgery by analyzing images and offering insights into diagnosis.

Telemedicine has gained popularity and medical students are increasingly exposed to virtual consulta-

tions as part of their training. During the ongoing conflict and other challenges in Ukraine, telemedicine has become an essential tool in providing healthcare to areas with limited access to medical facilities. The use of telemedicine has been on the rise, especially during the pandemic and the war, when access to healthcare has been restricted in some areas. Medical universities have integrated telemedicine into their curricula, allowing students to learn remotely and engage with real-world cases of digital healthcare. Medical students can learn by observing and participating in remote consultations, gaining real-world experience in diagnosing and treating patients through digital means. Additionally, AI-driven tools are being introduced to medical education, helping students to better understand diagnostics, medical imaging, and treatment planning.

Additionally, the universities have established partnerships with international institutions, allowing medical students to participate in online workshops, virtual patient simulations, and even telehealth internships. As (Diane N. Kenwright, Tim Wilkinson, 2018) stated that "continuing professional development (CPD) programs aim to promote lifelong learning based on on-going assessments by self or others, and aim to improve or maintain professional skills in domains such as clinical, leadership, administration, and education".

Simulation-based medical education is expanding in Ukraine, with university hospitals using advanced simulators to teach students essential skills. Ukrainian medical institutions have been incorporating these tools to ensure students can practise and perfect their clinical skills in a safe, controlled setting as mannequins simulate patient responses to more complex high-fidelity simulation systems before interacting with real patients.

Therefore, AI and technology have enabled medical students and professionals to access a wide range of global medical resources, research papers, and online conferences. Platforms like PubMed, ResearchGate, and specialized medical databases are now more accessible in Ukraine, allowing students to stay updated on global trends, breakthroughs, and best practices in medicine.

In response to the pandemic and ongoing disruptions caused by the war, medical universities have increasingly turned to online and hybrid models of training. Digital platforms, virtual classrooms, and online resources have become integral parts of the medical education system. Medical students can now access lectures, workshops, and study materials remotely, ensuring continuity in their education even in times of crisis.

However, there are challenges related to internet access, especially in war-affected areas, and not all students have access to the necessary technology for online learning. Some universities have worked to mitigate this by providing technological support and resources for students in need.

Medical education system is largely based on traditional classroom instruction, with a heavy emphasis on theoretical knowledge. However, there is a growing movement towards more modern, student-centered, and technology-integrated teaching methods. Many medical universities have been introducing simulation-based learning, virtual reality, augmented reality, and interactive learning modules to improve student engagement and provide more practical, hands-on experiences. AI technologies also assist in personalizing education for students, offering tailored learning paths based on individual progress, performance, and areas that need improvement. This is particularly beneficial in large classes where individualized attention is limited. The curriculum in medical schools is constantly evolving to keep up with the latest medical practices, research, and technological advancements. However, some institutions still face challenges in terms of outdated equipment, limited access to the latest medical technologies, and a lack of modern facilities.

There is a significant demand for healthcare professionals due to the ongoing crisis. Many medical schools are adapting their curricula to produce healthcare workers skilled in emergency medicine, trauma care, and mental health services, all of which are critical in times of conflict. Medical professionals are also being trained to work in war zones and to provide care to victims of the conflict, including both civilians and military personnel. As "employers may conceptualize quality in medical education with an emphasis on learning and teaching and employers' perspectives on the quality attributes of medical graduates" (Danah AlThukair, Julie Rattray, 2023).

Despite the progress, medical education faces several challenges:

– **outdated infrastructure:** some medical schools still operate with outdated classrooms, equipment, and medical devices; access to modern simulation technologies, such as robotic surgery simulators, is limited;

– **brain drain:** many highly skilled medical professionals leave Ukraine for better opportunities abroad, which impacts the country's ability to provide quality medical education and healthcare services; this has led to a shortage of qualified faculty members in certain specialties;

– **financial constraints:** many medical schools face financial difficulties due to limited government funding, which can affect the quality of education, resources, and faculty recruitment.

Despite these challenges, the quality of education in certain universities remains highly regarded as "medical graduates must attain a balance of soft skills, practical and clinical skills, and theoretical medical knowledge. Understanding employers' perspectives on quality in medical education will complement our existing understanding of quality in medical education" (AlThukair, D. and Rattray, J., 2023).

Nevertheless, the future of medical education is likely to continue evolving in response to technological advancements, the needs of the healthcare system, and international trends. Key factors that will shape the future of medical education include:

– further integration of AI, telemedicine, and VR/AR technologies into the curriculum;

– stronger partnerships with international institutions to raise the profile of medical schools;

– continued focus on training healthcare workers in emergency, trauma, and post-conflict care due to the ongoing war;

– potential for increased funding and government support for modernization efforts in the sector.

Conclusions

While Ukraine has made significant strides in adopting technology and AI in medical education, challenges remain. These include limited infrastructure in some regions, financial constraints, and the need for more widespread access to advanced technology. However, active participation in international medical education networks, along with government support for digital education, is likely to continue improving access to these innovations.

The adoption of technology and AI in medical education system is rapidly evolving, enabling students to gain better access to learning resources, enhance practical skills, and engage with cutting-edge tools in diagnosis and treatment. The integration of AI and digital technologies in medical curriculum is preparing future healthcare professionals to work more efficiently and effectively in a technologically advanced medical landscape. With continued investment in these technologies, medical education is poised to grow in sophistication and quality.

While medical education faces significant challenges due to the war and limited resources, the country is making strides in embracing technology and modern teaching methods to ensure that future healthcare professionals are well-prepared. With ongoing reforms and international collaboration. It means that medical education system is likely to continue improving, despite the obstacles it faces.

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"Яким би складним не здавалося життя, завжди можна щось зробити, щоб досягти успіху".

Стівен Хокінг
англійський фізик, теоретик

"Від природи, як від матері, легесенько спіє наука сама собою. Вона є всеродна й істинна вчителька, і – єдина".

Григорій Сковорода
український філософ, педагог

"Бути людиною означає мати усвідомлення того, що станемо перед Обличчям Божим і дамо відповідь, на що вжили ті дари, якими Він нас обдарував".

Святійший Патріарх Павло Сербський