THE USE OF VIRTUAL PATIENTS IN MEDICAL EDUCATION: IMPLEMENTATION METHODOLOGY AND EFFECTIVENESS ASSESSMENT

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Medical education is currently undergoing significant transformation due to limited access to real patients, increasing patient safety requirements, ethical considerations, and rapid digitalization of the educational process. In Ukraine, these challenges have been substantially intensified by the full-scale war, which has restricted traditional bedside teaching because of security risks, healthcare system overload, and prioritization of emergency care.

The aim of this article is to summarize methodological approaches to the implementation of virtual patients in medical education and to analyze the effectiveness of their use in developing clinical reasoning skills under conditions of limited clinical access. The paper presents the concept and classification of virtual patients and examines their role within a competency-based and student-centered educational model. Particular attention is given to the integration of virtual patients into lectures, practical classes, and independent student work. The role of the teacher is analyzed as a facilitator and moderator of learning, emphasizing pedagogical support and structured reflection. The main advantages of virtual patients are discussed, including improved patient safety, standardization of learning experiences, access to rare and complex clinical cases, and the opportunity to develop clinical reasoning without the risk of real-life errors. Key limitations and challenges are also outlined, such as the lack of physical patient contact, technical and organizational barriers, and the need for targeted faculty development. Approaches to assessing the effectiveness of virtual patients are described, focusing on knowledge acquisition, development of clinical reasoning, and student satisfaction. The findings suggest that virtual patients represent an effective and ethically sound educational tool that ensures continuity and quality of medical training in crisis conditions. Their implementation contributes to strengthening the resilience of medical education systems and preparing future physicians for clinical practice in complex and resource-limited environments.

Key words: medical education, virtual patients, clinical reasoning, digital learning, patient safety, wartime education.

Павлюкович Наталія, Павлюкович Олександр, Коротун Олена, Білоус Володимир. Використання віртуальних пацієнтів у медичній освіті: методика впровадження та оцінка ефективності

Медична освіта на сучасному етапі розвитку перебуває в умовах суттєвих трансформацій, зумовлених обмеженим доступом студентів до реальної клінічної практики, зростанням вимог до безпеки пацієнтів, етичними

викликами та активною цифровізацією освітнього процесу. В Україні ці проблеми набули особливої гостроти в умовах повномасштабної війни, коли традиційні форми клінічного навчання стали значною мірою обмеженими через безпекові ризики, навантаження на систему охорони здоров'я та пріоритет надання невідкладної допомоги.

Метою статті є узагальнення методичних підходів до впровадження віртуальних пацієнтів у медичну освіту та аналіз ефективності їх використання для формування клінічного мислення здобувачів освіти в умовах обмеженого доступу до реальних пацієнтів. У роботі розглянуто поняття та класифікацію віртуальних пацієнтів, їх місце у компетентнісно орієнтованій і студент-центрованій моделі навчання, а також можливості інтеграції у лекційний, практичний та самостійний компоненти освітнього процесу. Особливу увагу приділено ролі викладача як фасилітатора навчання, педагогічному супроводу та організації рефлексії. Проаналізовано основні переваги використання віртуальних пацієнтів, зокрема підвищення безпеки пацієнтів, стандартизацію навчального досвіду, доступ до рідкісних клінічних випадків та розвиток клінічного мислення без ризику помилки. Окреслено обмеження та виклики, пов'язані з відсутністю фізикального контакту, технічними бар'єрами та потребою в педагогічній підготовці викладачів. Показано підходи до оцінки ефективності віртуальних пацієнтів на основі аналізу засвоєння знань, формування клінічного мислення та рівня задоволеності студентів. Зроблено висновок, що віртуальні пацієнти є ефективним і безпечним інструментом забезпечення якості медичної освіти в кризових умовах та мають стратегічне значення для підвищення стійкості освітнього процесу в Україні.

Ключові слова: медична освіта, віртуальні пацієнти, клінічне мислення, цифрове навчання, безпека пацієнтів, воєнний стан.

Introduction. Medical education at the current stage of development faces a number of systemic challenges that significantly affect the organisation and quality of training for future doctors. One of the key limitations is the reduced access of students to real patients, due to increased safety requirements, ethical considerations, increased workload on clinical bases, and time constraints on clinical department teachers, who usually combine the educational process with practical activities.

These challenges have been significantly exacerbated by the russian federation's full-scale aggression in Ukraine and the introduction of martial law. Limited access to clinical departments, security threats, disruption to medical infrastructure and the priority of providing emergency care reduce the opportunities for traditional clinical training [1]. At the same time, the ethical aspects of medical training are becoming increasingly important, in particular responsibility for patient safety and the prevention of unjustified and unnecessary educational interventions that are not clinically necessary [2].

At the same time, the process of digitisation of education opens up new opportunities for the transformation of the educational process, in particular through the introduction of technology-enhanced educational solutions. In the modern paradigm of medical education, the key goal is not only to transfer theoretical knowledge, but also to develop clinical thinking – the ability to analyse symptoms, integrate data from medical history, laboratory and instrumental examination methods, form differential diagnostic hypotheses and justify clinical decisions. It is the maturity of clinical thinking that today determines a graduate's readiness for independent medical practice [3]. Traditionally, clinical thinking is formed in the process of direct work with patients, but in conditions of limited clinical access to patients, there is a need to find alternative teaching methods that allow the logic of clinical decision-making to be practised without risk to the patient.

In recent years, virtual patients (VP) have confidently taken an important place in the competence-oriented and student-centred model of medical education. They allow the creation of a safe and controlled learning environment in which students are actively involved in the clinical decision-making process, are responsible for choosing diagnostic and treatment strategies, and receive immediate feedback. SAs contribute to the standardisation of the learning experience, provide access to rare or complex clinical cases, and allow for repeated practice of clinical thinking algorithms. In the context of student-centred learning, VPs support individual learning pace, independent work and reflection, while maintaining the key role of the teacher as a facilitator of the learning process [4–6]. In view of this, the use of VPs may be a logical response to the current challenges of medical education and an effective tool for developing clinical thinking in conditions of limited access to real clinical practice for students.

A virtual patient is a digital educational tool that simulates a clinical situation in order to teach medical students clinical thinking, decision-making and approaches to patient management. VP reproduces key elements of a real clinical case, including complaints, medical history, physical examination results, laboratory and instrumental examination results, as well as the dynamics of the patient's disease depending on the student's decisions [7]. Unlike traditional teaching cases, VPs are interactive, require active student participation, and provide feedback on the correctness or appropriateness of the chosen clinical actions. The main didactic goal of VPs is not to

reproduce a clinical algorithm, but to develop the ability to analyse information, construct differential diagnostic hypotheses, and justify clinical decisions in conditions close to real practice, but without risk to the patient.

The implementation of different types of VPs largely depends on the functional capabilities of digital educational platforms. Modern systems support a wide range of didactic solutions – from simple case-based learning to complex interactive and scenario-based models that simulate the real process of clinical decision-making. Depending on the structure and level of interaction between the educational platform and the learner, VLEs are traditionally divided into several main types [5, 8]:

– linear virtual patients – involve going through a clinical case in a predetermined sequence of steps. The student receives information gradually, but their decisions do not change the course of the scenario. This type of VP is mainly used to acquire basic knowledge, clinical algorithms, and standardised approaches to the diagnosis and treatment of the most common diseases of internal organs. Such VPs are implemented on platforms focused on case-based learning and standardised training. Examples include individual CASUS modules [9], the Aquifer platform [10], and training cases within Learning Management Systems (Moodle, Canvas);

– branched virtual patients – characterised by the presence of alternative paths for the development of the clinical scenario depending on the student's decisions. The selected diagnostic or therapeutic steps influence the further course of the clinical case, allowing the consequences of correct and incorrect decisions to be simulated. This type of VP is effective for developing clinical thinking, responsibility for decisions made, and understanding cause-and-effect relationships. A classic platform for creating such scenarios is OpenLabyrinth [11], which supports complex networks of decisions and cause-and-effect relationships. Similar capabilities are also implemented in CASUS and vpSim, where the results of diagnostic or therapeutic actions chosen by the student directly influence the course of the clinical case;

– interactive virtual patients – provide active dialogue between the student and the educational platform, may include virtual communication with the 'patient', selection of medical history questions, interpretation of test results, and adaptive feedback. They contribute to the development of not only clinical thinking but also communication skills. Such models are implemented on the Body Interact [12] and Shadow Health [13] platforms and in extended CASUS scenarios;

– scenario-based virtual patients – focused on complex clinical situations involving interdisciplinary aspects, ethical dilemmas or crisis situations. They are often used in simulation training and are aimed at developing systematic thinking, teamwork and decision-making in complex and uncertain conditions. They are implemented on platforms that support simulation and team training, in particular CASUS, Body Interact, as well as in hybrid simulation environments integrated with simulation centres.

Thus, the variety of simulation types allows this educational tool to be adapted to different learning objectives, from acquiring basic knowledge to developing complex clinical and professional thinking. Choosing the right type of simulation is key to its effective implementation in medical education.

Virtual patients can be organically integrated into all the main components of the academic discipline, complementing traditional forms of teaching and increasing their effectiveness. In lecture courses, VPs should be used as an illustrative and problem-oriented tool. Fragments of clinical scenarios allow demonstrating the logic of clinical thinking, typical diagnostic errors, and decision-making algorithms, stimulating students' cognitive activity. During practical classes, VPs become the main means of forming clinical thinking. Working with scenarios allows students to analyse complaints, interpret the results of additional examination methods, form differential diagnostic hypotheses and justify their own clinical decisions in a safe environment. The results are discussed under the guidance of a teacher, who often acts as a facilitator. Within the framework of independent work, VPs provide the opportunity for asynchronous learning, repetition of material, and independent analysis of one's own mistakes, which contributes to the development of responsibility and self-reflection skills.

In our opinion, it is advisable to implement VPs in the educational process in stages. The first stage is to define learning objectives that should correspond to the expected programme outcomes and the competency model for training doctors. Subsequently, clinical scenarios are developed that take into account the level of student training and the specifics of the academic discipline. The scenarios can vary in complexity and provide alternative options for the development of the clinical situation. An important stage is the integration of laboratory and instrumental research methods into the clinical case, which brings the training closer to real clinical practice and contributes to the formation of skills in interpreting objective indicators. The final element is the organisation of feedback, which allows

students to evaluate their own decisions, realise their mistakes and improve their clinical thinking by analysing them.

In the process of using VPs in the educational process, the role of the teacher undergoes a significant transformation from a traditional source of knowledge to a facilitator, moderator, and mentor. The teacher not only presents the educational material but also organises the learning environment in which students are actively involved in analysing clinical situations, making independent decisions, and realising their consequences. The teacher's task is to guide students' thinking, ask questions that stimulate clinical thinking, and support the logic of differential diagnosis [4, 7]. Control of the educational process in the context of using VP is carried out not only through the assessment of the final result, but also through the analysis of the decision-making process. The teacher evaluates the students' activity, the consistency of their actions, the validity of their choice of diagnostic and therapeutic steps, as well as typical mistakes and difficulties. This approach allows identifying gaps in students' knowledge or thinking and timely adjusting the educational focus, adapting the further educational process to the real needs of students.

An integral part of effective work with VPs is pedagogical support and organised reflection [6]. After completing the clinical scenario, students analyse their own decisions, discuss alternative approaches and the consequences of the chosen case management tactics. Under the guidance of the teacher, a conscious attitude towards clinical thinking, the responsibility of a doctor and the ethical aspects of professional activity is formed. Reflection promotes the integration of theoretical knowledge with practical experience, the development of self-criticism and a readiness for continuous professional improvement. Thus, the active participation of the teacher in facilitating, controlling and reflecting on the learning process is a key condition for the effective use of VPs and the formation of mature, responsible clinical thinking in students.

The use of virtual patients in medical education has a number of significant **advantages**, which are particularly important in the context of martial law in Ukraine, where traditional forms of clinical training are subject to significant restrictions. One of the key advantages is *ensuring patient safety*, as VPs make it possible to minimise or completely eliminate the participation of real patients in the training process at the stages of developing basic clinical skills, which is especially important when working with vulnerable categories of patients, in particular those with incurable diseases, immunodeficiency

conditions or psycho-emotional instability [14]. During wartime, when the healthcare system is operating under increased stress and risk, reducing clinically unnecessary contact is ethically justified and appropriate.

An important advantage of introducing VRE into the educational process is *the standardisation of the learning experience*, which is impossible to fully achieve during traditional clinical training. VREs ensure that all students work with the same clinical scenarios, have access to the same diagnostic data, and undergo identical stages of clinical analysis. This is particularly relevant in wartime, when students' access to clinical databases is uneven and the learning process often takes place in a hybrid or remote format.

VS provide *access to rare or complex clinical cases* that may occur sporadically in real practice or be unavailable for educational purposes [7]. During wartime, the range of clinical cases in hospitals often shifts towards emergency care, which further limits the opportunities for students to learn about specific nosologies. Digital scenarios make it possible to compensate for these limitations and maintain the completeness of the curriculum. Another significant pedagogical advantage is the *opportunity to develop clinical thinking without the risk of error* [2]. In a virtual environment, students can make wrong decisions, analyse their consequences, and receive feedback without harming the patient. This format promotes the formation of a responsible attitude towards clinical decisions and reduces the fear of making mistakes, which is especially important in the stressful conditions of war. In addition, the use of virtual patients helps to increase student motivation and independence. Asynchronous access to learning materials, the ability to repeat scenarios multiple times, and elements of active interaction stimulate self-learning and student engagement, even when the learning process is interrupted by air raid sirens or forced relocation of students.

At the same time, the introduction of VPs into the routine educational process is accompanied by a number of **limitations and challenges**. One of the key ones is the *lack of real physical contact with the patient*, which makes it impossible to fully develop physical examination and interpersonal communication skills. In this regard, VPs cannot completely replace clinical practice and should only be considered as a supplement to it. *Technical and organisational barriers* remain significant, including unstable internet access, limited technical resources, and the need for digital infrastructure support, which is particularly relevant in wartime. An additional

challenge is the *risk of formal scripting*, where students focus on achieving results without a deep understanding of clinical logic, which requires active pedagogical support. The *need for pedagogical training of teachers* to work with VPs requires special attention. Effective use of this tool requires teachers to adopt new didactic approaches, the ability to facilitate the learning process, analyse students' decisions and organise reflection. Without proper training, there is a risk of reducing the educational value of VPs, especially in conditions of crisis stress on the medical education system.

Thus, virtual patients are a powerful tool for supporting medical education in wartime, but their effectiveness depends on a balanced combination with traditional forms of training, the technical readiness of educational institutions, and the methodological competence of teachers.

Assessing the effectiveness of VPs in medical education is a necessary component of their systematic implementation, especially in the context of martial law in Ukraine, when digital educational solutions often transition from being an auxiliary tool to the main format for ensuring the continuity of the educational process [1]. In our opinion, the effectiveness of VPs should be assessed according to several interrelated criteria that reflect both educational outcomes and students' subjective perception of learning. One of the basic criteria is the level of knowledge acquisition, which involves assessing students' theoretical training and ability to correctly interpret clinical information. An equally important criterion is the development of clinical thinking, which is considered to be the student's ability to integrate anamnestic, laboratory and instrumental data, form differential diagnostic hypotheses and justify clinical decisions. This aspect is particularly important in wartime, when access to real patients is limited and training must ensure that future doctors are prepared to work in conditions of uncertainty and resource scarcity. VPs make it easy and effective to simulate complex clinical situations without risk to the patient and with the ability to analyse the consequences of decisions made. An additional criterion of effectiveness, in our opinion, is the level of student satisfaction with the learning process, which reflects the acceptability of digital formats, motivation to learn, and subjective perception of the benefits of working with virtual patients. In the conditions of constant stress and instability characteristic of the martial law in modern Ukraine, a positive perception of the learning tool is undoubtedly an important factor in maintaining student engagement.

Various assessment methods can be used to evaluate these criteria. Student surveys allow data to be collected on the perception of the learning process, the level of complexity of scenarios, and the usefulness of feedback. Testing before and after completing a clinical scenario involving VPs allows for an objective assessment of the dynamics of students' knowledge and clinical thinking skills. Analysis of the clinical decisions made by students during the scenarios allows for the identification of typical mistakes, gaps in theoretical knowledge, and the effectiveness of pedagogical support. It is also important to compare the results of training with traditional teaching methods, which allows assessing the added educational value of VPs in crisis conditions.

The prospects for the development of the use of virtual patients in medical education are closely linked to further digital transformation and wartime experience. One promising area is the integration of VPs with simulation training, which will allow for the active development of medical students' cognitive and practical skills. The use of artificial intelligence elements to adapt scenarios to the student's level of training and personalise feedback has significant potential [15]. Another important aspect is the expansion of interdisciplinary scenarios that reflect real clinical challenges in wartime and require comprehensive clinical thinking with effective teamwork skills.

Conclusions. Thus, the use of virtual patients in medical education is an effective response to current systemic challenges, including limited access to clinical practice, increased patient safety requirements, and martial law conditions in Ukraine. Virtual patients ensure the formation of clinical thinking, standardisation of learning experiences, and safe practice of clinical decisions without risk to the patient. Their effectiveness largely depends on pedagogically sound implementation, the active role of the teacher, and integration with traditional forms of learning. Further development of this approach, taking into account digital innovations and interdisciplinary scenarios, is of strategic importance for ensuring the sustainability and quality of medical education in crisis conditions.

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