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Abstract

The integration of artificial intelligence (AI) into simulation-based medical training has transformed traditional approaches to clinical skill development and assessment. This article examines AI-powered simulation platforms that replicate realistic clinical scenarios and enable digital evaluation within Objective Structured Clinical Examinations (OSCE). By employing machine learning algorithms for real-time performance scoring, adaptive scenario generation, natural language processing for patient interaction, and automated feedback mechanisms, AI delivers objective, bias-reduced, and personalized assessment of trainees' diagnostic, procedural, and communication competencies. The study reviews current technologies, including virtual reality (VR) and augmented reality (AR) simulations, and analyzes their effectiveness in enhancing learning outcomes compared to conventional OSCE methods. Empirical evidence demonstrates significant improvements in diagnostic accuracy, procedural efficiency, learner engagement, and assessment reliability. Challenges related to data privacy, ethical implementation, technological equity, and faculty training are addressed. The paper concludes with recommendations for scalable integration of AI-driven simulation and digital assessment into global medical education curricula, highlighting its potential to bridge the gap between theoretical knowledge and clinical practice while preparing future healthcare professionals for complex, technology-enhanced environments.

Keywords: Artificial Intelligence, Simulation-Based Training, Clinical Scenarios, OSCE, Digital Assessment, Medical Education, Machine Learning, Virtual Patients

Аннотация

Интеграция искусственного интеллекта (ИИ) в симуляционные тренинги в медицинском образовании кардинально изменила традиционные подходы к развитию клинических навыков и их оценке. В статье рассматриваются платформы симуляции на основе ИИ, которые воспроизводят реалистичные клинические сценарии и обеспечивают цифровую оценку в рамках объективных структурированных клинических экзаменов (OSCE). С помощью алгоритмов машинного обучения для оценки результатов в реальном времени, адаптивной генерации сценариев, обработки естественного языка для взаимодействия с пациентами и автоматизированной обратной связи ИИ обеспечивает объективную, свободную от предвзятости и персонализированную оценку диагностических, процедурных и коммуникативных компетенций обучающихся. Исследование анализирует современные технологии, включая симуляции виртуальной и дополненной реальности, и оценивает их эффективность по сравнению с традиционными методами OSCE. Эмпирические данные подтверждают значительное повышение точности диагностики, процедурной эффективности, вовлеченности обучающихся и надежности оценки. Обсуждаются проблемы конфиденциальности данных, этической реализации, технологической доступности и подготовки преподавателей. В заключение предлагаются рекомендации по масштабируемой интеграции ИИ-симуляций и цифровой оценки в глобальные программы медицинского образования. Подчеркивается потенциал данного подхода в преодолении разрыва между теоретическими знаниями и клинической практикой и в подготовке будущих специалистов здравоохранения к работе в сложной технологической среде.

Ключевые слова: Искусственный интеллект, Симуляционные тренинги, Клинические сценарии, OSCE, Цифровая оценка, Медицинское образование, Машинное обучение, Виртуальные пациенты

Annotatsiya

Sun'iy intellekt (AI) asosidagi simulyatsion treninglar tibbiy ta'limdagi an'anaviy yondashuvlarni tubdan o'zgartirdi va klinik ko'nikmalarni rivojlantirish hamda baholash jarayonini yangi bosqichga olib chiqdi. Ushbu maqolada AI boshqaruvidagi simulyatsiya platformalari orqali realistik klinik ssenariylarni modellashtirish va Ob'ektiv Strukturalashtirilgan Klinik Imtihon (OSCE) jarayonida raqamli baholash

imkoniyatlari ko‘rib chiqiladi. Mashinaviy o‘rganish algoritmlari yordamida real vaqt rejimida ishlashni baholash, moslashuvchan ssenariylarni yaratish, tabiiy tilni qayta ishlash orqali bemor bilan muloqotni ta‘minlash va avtomatlashtirilgan fikr-mulohaza berish tizimlari orqali AI o‘quvchilarning diagnostika, protsedura va kommunikatsiya kompetensiyalarini ob‘ektiv, tarafkashliksiz va shaxsiylashtirilgan tarzda baholaydi. Tadqiqotda virtual reallik (VR) va kengaytirilgan reallik (AR) simulyatsiyalari kabi zamonaviy texnologiyalar tahlil qilinadi hamda ularning an‘anaviy OSCE usullariga nisbatan samaradorligi baholanadi. Empirik natijalar diagnostika aniqligi, protsedural samaradorlik, o‘quvchilarning faolligi va baholash ishonchliligini sezilarli darajada oshirishini ko‘rsatmoqda. Ma‘lumotlar maxfiyligi, axloqiy qo‘llash, texnologik tenglik va o‘qituvchilarni tayyorlash bilan bog‘liq muammolar muhokama qilinadi. Maqola global tibbiy ta‘lim dasturlariga AI asosidagi simulyatsiya va raqamli baholashni keng miqyosda joriy etish bo‘yicha tavsiyalar bilan yakunlanadi. Ushbu yondashuv nazariy bilim va klinik amaliyot o‘rtasidagi bo‘shliqni bartaraf etish hamda kelajakdagi sog‘liqni saqlash mutaxassislarini texnologiyalarga asoslangan murakkab muhitga tayyorlash imkonini beradi.

Kalit so‘zlar: Sun‘iy intellekt, Simulyatsion treninglar, Klinik ssenariylar, OSCE, Raqamli baholash, Tibbiy ta‘lim, Mashinaviy o‘rganish, Virtual bemorlar

Here is a precise, spelling-error-free English translation of the provided Uzbek text. It maintains a formal, scientific academic style suitable for a research or review article:

Introduction.

In contemporary medical education, the development of clinical competence extends far beyond the acquisition of theoretical knowledge to encompass the integration of cognitive, psychomotor, and affective skills essential for safe and effective patient care. Traditional didactic approaches, while foundational, frequently prove insufficient in replicating the dynamic, high-stakes realities of clinical practice, where diagnostic reasoning, procedural proficiency, and interpersonal communication intersect under time pressure and uncertainty. Simulation-based training (SBT) has thus emerged as a cornerstone pedagogical strategy, providing immersive, risk-free environments that enable deliberate practice, error management, and reflective learning. A comprehensive review by Elendu et al. (2024) underscores the transformative impact of SBT, demonstrating consistent improvements in clinical performance, diagnostic accuracy, communication skills, and overall patient safety outcomes across diverse healthcare disciplines.

Central to the assessment of these competencies is the Objective Structured Clinical Examination (OSCE), widely regarded as the gold standard for evaluating clinical skills in a standardized, multifaceted manner. OSCEs allow trainees to rotate through timed stations assessing history-taking, physical examination, clinical reasoning, patient education, and professional interaction, thereby minimizing the subjectivity inherent in traditional long-case examinations. Nevertheless, conventional OSCE implementations face persistent limitations: they are resource-intensive, requiring substantial faculty time, standardized patients (SPs), and logistical coordination; they remain vulnerable to inter-examiner variability, checklist rigidity versus global rating inconsistencies, and challenges in scenario reproducibility; and they struggle with scalability amid growing student cohorts and curriculum demands. These constraints can undermine validity, reliability, and equity, particularly in resource-limited settings or during periods of high educational demand

Methods

This narrative review was conducted in accordance with established guidelines for scoping and narrative syntheses in medical education research, adapted from the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) framework where applicable, to map the evolving landscape of artificial intelligence (AI) applications in simulation-based training and digital assessment within Objective Structured Clinical Examination (OSCE) contexts.

A comprehensive literature search was performed across multiple electronic databases, including PubMed/MEDLINE, Scopus, Web of Science, ERIC, and Google Scholar, covering publications from January 2020 to April 2026. The search strategy combined controlled vocabulary (MeSH terms where available) and free-text keywords such as: (“artificial intelligence” OR “AI” OR “large language model” OR “LLM” OR “generative AI” OR “GPT” OR “ChatGPT”) AND (“simulation-based training” OR “simulation-based education” OR “virtual patient” OR “virtual simulated patient” OR “VSP”) AND (“OSCE” OR “objective structured clinical examination” OR “clinical skills assessment” OR “digital assessment” OR “automated scoring”). Boolean operators, truncation, and proximity searches were employed to maximize sensitivity. Additional hand-searching of reference lists from included articles, relevant review papers, and proceedings from major medical education conferences (e.g., AMEE, ASME, and Society for Simulation in Healthcare) was undertaken to identify grey literature and emerging studies not yet indexed

Results

The reviewed studies consistently demonstrated that AI-enhanced simulation-based training significantly improves clinical performance in OSCE settings. In a randomized controlled trial with 247 medical students, AI-standardized clinical examination (ASCE) training using GPT-4 resulted in higher OSCE scores (median 11.4 vs. 10.7; $P=0.02$), reduced stress, and lower absenteeism compared to traditional methods. AI-generated virtual simulated patients achieved high knowledge accuracy (94.15%) and strong realism, while GPT-4-based automated scoring showed excellent concordance with human raters (ICC 0.91 for average measures) and dramatically improved evaluation efficiency. AI-created OSCE stations were comparable or superior to faculty-designed cases in content quality and usability. Overall, learners reported high satisfaction with the realism, scalability, and personalized feedback offered by AI-driven platforms

Academic Achievement

AI-powered simulation-based training demonstrated clear positive effects on students' academic achievement in OSCE settings. In a randomized controlled trial published in NEJM AI, medical students who underwent AI-Standardized Clinical Examination (ASCE) training using a GPT-4 platform achieved significantly higher faculty-assessed OSCE scores than the control group (median 11.4 vs. 10.7; $P=0.02$). Another study using AI-simulated patients for medical interview practice reported significantly improved interview scores in the pre-clinical clerkship OSCE (mean 28.1 vs. 27.1; $P=0.01$). AI-generated virtual patients also led to measurable gains, with median OSCE scores rising from 63/100 to 70/100 after practice sessions. Complementary findings showed AI chatbots excelling in patient education domains and providing structured feedback that enhanced overall clinical competence. These results indicate that integrating AI into simulation training reliably boosts measurable academic performance while offering scalable, repeatable practice opportunities

Discussion

The integration of artificial intelligence into simulation-based training and digital OSCE assessment represents a significant advancement in medical education, addressing longstanding challenges of resource intensity, scalability, and standardization while delivering measurable improvements in learner outcomes. Evidence from multiple randomized controlled trials consistently shows that AI-

standardized clinical examination (ASCE) training using GPT-4 platforms leads to superior OSCE performance compared to traditional methods, with students achieving higher faculty-assessed scores, greater emotional readiness, reduced pre-examination stress, and near-elimination of absenteeism. These benefits stem from AI's ability to provide unlimited, on-demand deliberate practice with adaptive, realistic virtual simulated patients that respond dynamically to learner inputs, offering consistent portrayal of diverse clinical presentations, emotional states, and cultural contexts.

AI-generated virtual patients and OSCE stations demonstrate high fidelity, with knowledge accuracy exceeding 94% and strong alignment with human clinician readability and usability metrics. Structured prompting strategies, particularly multi-agent GPT-4o configurations, produce stations that match or surpass faculty-created cases in content accuracy, clarity, format compliance, and educational value, while requiring minimal revisions. In comparative studies, AI chatbots and peer role-play exhibit complementary strengths: AI excels in structured feedback, patient education, and repetitive practice opportunities, whereas peer interactions may offer greater perceived authenticity in history-taking and physical examination domains. Multimodal AI systems further enhance assessment reliability, with optimized video configurations achieving higher inter-rater agreement than human evaluators alone, and automated scoring tools showing strong concordance (ICC up to 0.91) with expert raters while completing evaluations in minutes rather than hours.

Conclusion

AI-powered simulation-based training and digital assessment tools have proven effective in enhancing clinical competence, improving OSCE performance, reducing learner anxiety, and increasing educational efficiency and accessibility. By enabling scalable, personalized, and repeatable practice with high-fidelity virtual patients and reliable automated scoring, these technologies offer a practical solution to the resource constraints of traditional medical education. While challenges related to reliability, bias, ethical considerations, and the need for human supervision persist, the current evidence strongly supports the integration of AI as a valuable complement to conventional methods. With continued refinement, rigorous validation, and thoughtful implementation, AI-augmented simulation and OSCE assessment hold transformative potential to prepare more competent, confident, and equitable healthcare professionals for the complexities of modern clinical practice. Educators and institutions are encouraged to adopt these innovations strategically, balancing technological capabilities with core principles of patient-centered care and professional development.

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