Creative and generative artificial intelligence for personalized medicine and healthcare: Hype, reality, or hyperreality?

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***Experimental Biology and Medicine* 2024; 248: 2497–2499. DOI: 10.1177/15353702241226801**

Introduction

Creative artificial intelligence (AI) refers to the applications of AI techniques that empower computers to perform tasks (e.g. creating art, music, storytelling, writing, and interactive decision-making) usually linked with human cognition, creativity, and imagination. Creative AI platforms often use generative models such as neural networks and other machine learning techniques to generate novel, innovative, and meaningful outputs.

Generative artificial intelligence (GenAI) is a subdomain of creative AI, that can assist in generating new content, data, information, or insight based on patterns and structures learned from training on very large data sets. Generative AI then uses prompts to create context-appropriate content on its own, often in a way that mimics human creativity. Large language models (LLMs) are a type of generative AI particularly designed for natural language processing (NLP), understanding, and generation of a sequence of contextually relevant material.

Personalized medicine and care have been significantly advanced in recent years through the extensive use of AI.[1] LLMs such as OpenAI's GPT (Generative Pre-trained Transformer) and ChatGPT series are powerful tools and show promising results in various applications in medicine and healthcare[2–5] along with other innovative technologies in AI and precision medicine.[6,7] Some of the applications of GenAI in healthcare include content creation, conversational agents, and text summarization.[8–11]

GenAI, including LLMs, has the potential to play a significant role in advancing personalized medicine through improving data analysis, pattern recognition, and prediction. By analyzing a very large amount of multimodal[5,12] and multidimensional clinical and administrative data, including genetic information, electronic health records, socioeconomic determinants of health, and environmental and lifestyle data, GenAI detects patterns of interest and generates new clinical insights. By revealing and identifying patterns and correlations in this integrated data set, GenAI can support understanding the unique attributes of individuals and predicting and infer possible health outcomes. It can also assist in the early diagnosis of diseases by highlighting specific patterns, which allows personalized and targeted treatment plans based on the patient's specific risk factors.

GenAI can play a role in pharmaceutical drug discovery and development[4] to empower personalized and customized treatments and interventions for individuals or communities, enhance health outcomes, and impact disease susceptibility by predicting potential drug candidates using existing biological, genomics, and biomedical data. It can also assist physicians in clinical decision-making by recommending personalized treatment options. Moreover, GenAI has shown significant potential in educating patients and enabling them to actively participate in their health-care decisions and adhere to personalized treatment plans.

It is important to note that while GenAI holds great promise in personalized medicine, some major challenges and limitations need to be considered such as the need for robust and multimodal data sets, eliminating exacerbated biases, ethical and legal considerations regarding patient confidentiality and consent, lack of explainability and interpretability of the models,[13,14] and the need for clinical validation and evaluation of AI-generated recommendations, insights, and actions.[15]

GenAI relies profoundly on the data it is trained on. If the training data are biased, non-representative, or incomplete, the generated results may also show biases or inaccuracies.[16] Personalized medicine requires diverse and representative data sets to ensure that the AI models can cater to different individuals and communities. If the training data are skewed, it may not generalize well to underrepresented groups. Class imbalances when sufficient data for training are not available can also give rise to biased and unfair results. This is especially prevalent in the case of rare

ISSN 1535-3702

diseases that often have small patient cohorts.[17] Personalized medicine often involves sensitive health data. Maintaining patient privacy and adhering to ethical standards are crucial. GenAI models may inadvertently reveal private information if not designed and implemented with privacy in mind.[18] Safeguarding robust security measures and data anonymization is a constant challenge. Moreover, as the task of the GenAI algorithm is usually to generate the next token (i.e. in the case of LLMs, to generate the next word), they are prone to hallucination, defined as the generation of fabricated content.[19] As imaginable, this is of particular concern in the biomedical field, especially when patients are involved, and their health is at stake.

Therefore, the integration of GenAI models into clinical practice requires rigorous validation to ensure their reliability and effectiveness. Limited clinical validation studies may hinder the adoption of these models in real-world healthcare settings. Regulatory bodies and health-care professionals must be cautious about relying on AI without sufficient convincing evidence of its clinical utility.[20] Another issue that GenAI is dealing with is related to keeping up with the pace of change in fast-evolving disciplines such as medicine. There is a high probability that the GenAI models become outdated quickly; therefore, they need to constantly adapt to novel medical findings and incorporate them into their models. In addition, many GenAI models are considered "black boxes" because they can be very hard, or in many cases impossible, to interpret how they come to a particular decision or recommendation.[20] This is specifically important in mission-critical domains such as personalized medicine, where both clinicians and patients need justifications to understand and trust the underlying reasoning behind AI-generated recommendations.

Despite the aforementioned challenges and limitations, GenAI provides great opportunities to advance personalized medicine. As the field continues to evolve, addressing the challenges will be crucial to achieving ethical, responsible, equitable, value-based, and trustworthy AI models in personalized medicine.

Thematic issue on health AI

This thematic issue on Health AI includes various contributions presenting results on theory, methods, systems, and applications of AI in healthcare and biomedicine.

To identify the subpopulation that can benefit the most from a statin treatment plan while avoiding the risks and choosing the optimal initial statin treatment plan, Yew *et al.*[21] proposed a five-step Decision Rule for Statin Treatment pipeline for personalized statin treatment. Thomas *et al.*[22] proposed a data-driven parameter estimation approach in the domain of wearable medical devices to calculate the trust score, a relative measure of the trustworthiness when different devices are evaluated in the same test conditions and using the same Bayesian structure. Werner *et al.*[23] presented a pipeline in which machine learning techniques, including the explainable hierarchical clustering method, are used for automatic identification and evaluation of subtypes of hospital patients and improved risk prediction for those admitted in a large UK teaching hospital during 2017–2021.

Alwuthaynani *et al.*[24] presented research on predicting which patients will progress from mild cognitive impairment (MCI) to Alzheimer's disease (AD) using the class decomposition transfer learning (CDTL) model to detect Alzheimer's progression. This model helps clinicians in identifying individuals at risk for AD and those with the earliest signs of clinical impairment, so they can implement therapeutic or preventive interventions at the early stages of disease. Liu *et al.*[25] presented a study to construct and evaluate a deep learning model, utilizing ultrasound images, to accurately differentiate benign and malignant thyroid nodules. Tang *et al.*[26] proposed using Pharmacophore-Based Virtual Screening and Machine Learning for the discovery of Subunit-Selective GluN1/GluN2B NMDAR. Yang *et al.*[27] proposed the Quantum-based Oversampling Method (QOSM) to address challenges in highly imbalanced and overlapped data sets, which are prevalent in biology and medical sciences.

DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FUNDING

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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