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Short Communication

The Impact of Artificial Intelligence on Precision Medicine

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Artificial Intelligence (AI) is transforming how precision medicine is practiced. For many years, precision medicine was an ambitious goal: to provide every patient with prevention and treatment tailored to their biology, lifestyle, and environment. Today, AI helps make that goal more achievable by aggregating and interpreting vast amounts of health information, including genetic data, electronic health records, medical images, laboratory results, and data from wearable devices. Rather than treating patients with a general "one-size-fits-all" model, AI enables clinicians to identify patterns unique to each individual. This supports earlier diagnosis, more accurate risk assessment, and the selection of treatments more likely to work for a particular patient. Here are several advantages and a shortcoming of using AI for patient treatment:

Improving diagnosis and early detection: One of the clearest effects of AI is evident in medical diagnosis. Deep learning systems, including convolutional neural networks, can analyze medical images such as X-rays, CT and MRI scans, pathology slides, and dermatological photographs. In some cases, these systems have achieved performance comparable to, or even better than, that of human specialists [1]. AI can detect subtle abnormalities that may be difficult to identify during a routine examination [2]. For example, researchers are studying and applying AI to detect lung cancer, diabetic retinopathy, skin cancer, and certain rare diseases [3]. Earlier and more accurate detection can give patients access to treatment at a stage when the disease may be easier to control. However, AI should be viewed as a tool that supports clinical judgment rather than replacing healthcare professionals.

Supporting genomic medicine and drug development: Genomic information is central to precision medicine, but interpreting it can be highly complex [4]. AI can analyze large genomic datasets to identify genetic variants linked to disease risk, treatment response, or adverse drug reactions [5]. This may help clinicians select therapies better suited to a patient's biological characteristics. AI is also shaping the development of new medicines [6]. Conventional drug development is often expensive, time-consuming, and uncertain [7]. Many potential treatments fail in clinical trials because they are ineffective or unsafe [8]. AI can help researchers predict how drug molecules may interact with biological targets, identify promising compounds, and determine which patient groups are most likely to benefit from a particular treatment [9]. This approach may make clinical trials more efficient and support the development of therapies for smaller patient groups, including treatments for rare diseases. In some cases, AI could also support highly individualized, rather than "one-size-fits-all," treatment strategies, tailoring decisions to a single patient rather than a broad population.

The importance of data quality and integration: Despite its promise, AI in precision medicine faces several practical challenges. AI systems depend heavily on the quality, accuracy, and diversity of the data used to train them [10]. Healthcare information is often incomplete, inconsistently recorded, or fragmented across hospitals and software systems. Electronic health records (EHRs) may also use different formats, making it difficult to integrate information from multiple sources [11]. These data silos can limit AI effectiveness. If important information is missing or poorly standardized, an algorithm may produce unreliable conclusions [12]. Improving interoperability, data-sharing practices, and common standards will therefore be essential to the responsible development of AI-based precision medicine. Patient privacy is another major concern. Genomic and health data are highly personal, and their misuse could have serious consequences. Strong safeguards are needed to ensure that patient information is collected, stored, and used securely. Patients should also be informed about how their data will contribute to research and clinical care.

The risk of bias and unequal access: AI systems can unintentionally reproduce or worsen existing healthcare inequalities [13]. If an algorithm is trained primarily on data from a single ethnic, socioeconomic, or geographic group, it may perform less accurately for people underrepresented in that dataset [14]. This can lead to missed diagnoses, inappropriate treatment recommendations, or unequal access to care. For this reason, AI systems must be tested on diverse, representative populations. Their performance should be monitored regularly after implementation, not only during development. Developers and healthcare institutions should also conduct systematic bias assessments and implement corrections when disparities are identified. Access is another concern. Advanced AI technologies may initially be available only in well-funded hospitals or wealthy countries [15]. If these tools are not distributed fairly, they could widen existing healthcare disparities rather than reduce them.

Transparency and clinical trust: Some AI systems are described as "black boxes" because they generate predictions without clearly explaining how they arrived at them [16]. This lack of transparency can make clinicians reluctant to rely on AI, especially when decisions involve serious diagnoses or potentially harmful treatments [17]. Explainable AI may help address this problem by showing which clinical, genetic, or imaging features influenced a recommendation [18]. Even when an explanation is available, however, it should not be assumed to be automatically correct. Clinicians must still be able to question the output, compare it with other evidence, and override it when necessary. Building trust will require more than technical improvements. Healthcare professionals need appropriate training, and AI systems must be evaluated in real clinical settings. Their usefulness should be measured not only by accuracy but also by their impact on patient outcomes, safety, workload, and equality.

Conclusion

The future of precision medicine will depend on close collaboration between healthcare professionals and AI systems. AI is unlikely to replace doctors; instead, it may serve as cognitive support, helping clinicians process information that would otherwise be too extensive or complex to analyze. By integrating genomic, clinical, imaging, environmental, and lifestyle data, AI could make healthcare more predictive and preventive. It may help identify individuals at high risk of developing a disease before symptoms appear, enabling earlier interventions. Continuous data from wearable devices could also support ongoing monitoring and more timely treatment adjustments [19]. Nevertheless, technological progress alone will not guarantee better healthcare. The benefits of AI will depend on responsible regulation, secure data practices, transparent algorithms, diverse datasets, and meaningful involvement from patients and healthcare professionals. If these conditions are met, AI could help make precision medicine more effective, personalized, and proactive. If they are ignored, it could reinforce existing problems in healthcare. Ultimately, the greatest value of AI will come from using it carefully and ethically—not as a substitute for human care, but as a tool that helps clinicians make better-informed decisions for individual patients.

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