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AI in Personalized Medicine: Transforming Treatment Plans through Precision Health

Nahid Neoaz[1], Heta Hemang Shah[2], Hira Zainab[3*]

[1]Wilmington University, USA

[2]Independent Researcher USA

[3]American National University

[1]nahidneoaz@yahoo.com, [2]Heta2973@gmail.com, [3]hira.zainab72@gmail.com

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Corresponding Author

Hira Zainab

hira.zainab72@gmail.com

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ABSTRACT

Integrating The application of AI in healthcare has advanced over the last decade and is most prominent in personalized medicine. Due to ML and DL algorithms, AI is helping in better prognosis, customized interventions, and better results in a number of health disorders. It seeks to offer customized treatment according to the various features of each patient, and not generic methods like were initially used. Big data is being incorporated with the help of AI in individualized medicine by using elements like genetics, past health records, and surroundings to constitute threats of diseases and recommend particular courses of treatment. This paper seeks to review the various aspects of AI in personalized medicine, the application of AI, the advantages of AI, the disadvantages of AI, and the future of AI in precision health.

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INTRODUCTION

Recent developments in technology have changed the face of healthcare, especially due to the development of precision medicine. It was also a medical model in which patients with given signs of illness or similar diseases were given particular therapeutic interventions regardless of the attendees' genetic, environmental, or behavioral differences [1]. This idea of healthcare, acceptable for all, was effective in certain scenarios but was not conducive to providing the optimal treatment for every client. It failed to capture the relationship between the environment and patients' behavior, which can significantly influence therapy responses. Where increasing attention has been paid to the fact that the healthcare system needs to be redesigned to be patient-centered. In light of this, it is now possible to talk about the usage of precision health and medicine, allowing for better personalization of the treatment process [2].

The concept of personalized medicine purports to cater for each patient as a different individual by taking into account not only the genetic predispositions, the environment, or behaviors and, therefore, facilitates the formulation of better-targeted treatment plans [3]. This has proven to have a very positive implication of improved patient care because the doctor is in a position to forward to the patient treatments that are specific to them as opposed to general approaches that usually do not yield the same results. Taking the lead in this innovation is Artificial Intelligence (AI) which has emerged as a crucial mechanism that enhances the improvement of personalized healthcare services. AI comprises of other technologies like, ML and DL, which are capable of analyzing large volumes of healthcare data and extracting information from these inputs [4].

They assist healthcare providers in using genetic, clinical and environmental data to benefit patients in ways that before could not be imagined. The ability of AI to analyses and make meaning out of the aforementioned data types in real time is revolutionizing disease prevention, prediction, and cure. AI plays numerous roles in the future of PM as shown below. Generative models can have access to big data from EHRs, genetic tests, and even real-time patient data, and with such data, they can even foresee the patient's disease risk and recommend relevant treatment options [5]. Through these technologies, AI can predict other patients' reactions more accurately, making the efforts of clinicians more focused and precise, reducing the trial-and-error method employed by many clinicians in the medical field. It can eliminate bad interactions with drugs, lower expenses in healthcare, and foster

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high patient satisfaction and improved results [6].

Moreover, the application of AI in healthcare is advancing the understanding of the genetic profile of diseases and creating new and more effective treatments than conventional treatments. They have also been applied most significantly in the therapeutic areas of oncology, cardiology, and neurology [7]. For instance, in tumor therapy, the application of AI enables oncologists to explore the specific mutation that has prompted the formation of a particular tumor and the most appropriate targeted therapies to be used. In cardiology, conversely, AI can be applied to recognize a patient's hereditary background for heart diseases so that the necessary preventions against cardiovascular diseases or treatment can be provided early [8].

Likewise, in neurology, AI is aiding the tracing of early symptoms of neurodegenerative diseases such as Alzheimer's and Parkinson's in order to offer timely and efficient treatment. However, there is a few barriers and things to consider concerning the application of AI in personalized medicine. That is why it is a major concern to protect patients' information, especially in the area of genomics, because these are sacred details of a patient [9]. It is a legal requirement that the AI systems use patient data to obey certain regulations like the Health Insurance Portability and Accountability Act, which is HIPAA in the United States that governs releasing patient information. Furthermore, there can be implicit bias; generally, AI learning from biased data is likely to enhance or even expand health inequalities in society, especially to unpopular groups. It remains critical for each AI system to be trained on a variety of datasets to provide quality health care to patients regardless of their genetic makeup color, or financial muscle [10].

Moreover, adopting such technologies into the existing frameworks for delivering healthcare services has technical and implementation complexities. One possible implementation problem of AI-based personalized medicine is the absence of an adequate technology environment in many healthcare systems, especially in developing countries. However, a lack of personnel knowledge to interact with AI can also impede improving the efficiency and capabilities of those systems in a healthcare facility [11]. This calls for massive training, acquisition of equipment, and support for clinicians in order to bring about efficient deployment of AI tools in clinical practice. However, it is important to note that there are certain impediments to the use of AI in the field of personalized medicine. This is where AI has the potential to transform how healthcare is delivered by ensuring it is accurate, fast and personalized for the patient concerned. With the progression of advancement, it

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is thought that AI will increasingly play significant roles in the field of precision medicine, both in the therapeutic management of patients and in the modification of therapeutic strategies in the future [12].

Additionally, as artificial intelligence systems are getting more complicated, they will act as the primary tools for forecasting diseases and preventing them, and so changing a person's approach to health from acute to preventive [13]. The current paper will expand on the topic of how AI can be utilized for the enhancement of personalized medicine and how these technologies are implemented, the kinds of applications that AI can be applied to in precision health, the pros and cons of using AI for individualized treatments, and the potential that AI has in revolutionizing health care in the future. The next sections will further elaborate on these issues to give the readers some insights into control. With the help of this innovation, AI has been changing the conventional practices in healthcare management and patient treatment [14].

PERSONALIZED MEDICINE: AN OVERVIEW

Personalized or precision medicine is a breakthrough concept in healthcare oriented toward achieving optimal treatment for every patient of their distinct features. Unlike conventional medicine, which delivers interventions to patients mechanistically by treating all patients with a similar disease type similarly, personalized medicine adopts the patient-centered approach that considers individual genetic factors, environment and lifestyle [15]. It is also helpful for treatments because the applying therapies will also be crafted to fit the patient, increasing the effectiveness of treatment while reducing the unwanted side effects.

Genomics and Precision Health: Genomic data, therefore, is one of the pillars of personalized medicine. In recent decades, knowledge of mapping an individual's genome has dramatically improved and fine details can now be elucidated. Since doctors have knowledge about probable genetic mutations and occurrences of specific diseases, they can expand definitively the ways of treatment for every patient [16]. For example, one may find a high incidence of some types of cancer – for example, breast or ovarian – in persons with certain gene defects (BRCA1, BRCA2) this is important as it helps label the mutations early and enables the formulation of treatment regimens, which directly attack such gene changes, thus improving the patient's success rate. Besides personalized medicine also includes data regarding the patient other than genealogy [17]. It consists

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of family history, environmental factors and lifestyle factors. If the professional is aware of these numerous factors, they can not only cure diseases but also determine if a particular disease is likely to develop in the distant future.

Personalized Drug Therapies: Personalized medicine goes a step forward in understanding an individual's genetic makeup and combining such knowledge with their way of life and past medical history to explain how an individual can respond to specific treatments or drugs. It has thus become relevant, especially in the area of pharmacology, due to the integration of pharmacogenomics (differences in drug responses based on genetic differences). Thanks to artificial intelligence (AI), volumes of data, including genetics, medical history, and environment, can be accurately analyzed to determine the most potent and non-toxic treatment plans for patients [18]. In this way, personalized medicine avoids potential drug interactions since it reveals how people are likely to react to different medications. For instance, those with genetic predispositions have various ways in which they process or break down drugs, which may influence the medication's effectiveness or have toxic results. Personalized medicine, in relation to drug therapies, minimizes the occurrence of these risks since the correct dosage of the drug is administered to the right patient at the right time [19].

THE ROLE OF ARTIFICIAL INTELLIGENCE IN PERSONALIZED MEDICINE

Personalized medicine is another area where Artificial Intelligence (AI) has assumed a critical role in improving treatment processes by basing them on accurate data. Machine learning (ML) and deep learning (DL) in health care enable the use of big data to make accurate predictions about diseases, relevant and timely individualized care decisions, and patient surveillance [20]. Such concepts make it possible for healthcare professionals to journey from the administrative type of therapies in dealing with diseases to more personalized treatments that consider the patients' genetic, medical environment, and lifestyle factors [21].

Predicting Disease Risk: The most significant area of impact is the use of artificial intelligence in predictive biomarkers where the risk of getting a particular disease is accurately forecasted. An individual's propensity for developing specific diseases can also be accurately predicted using AIs based on the large databases collected. These algorithms work in combination with genetic information, medical history, and lifestyle, which helps healthcare providers use the risk profile as a

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tool for providing personalized prevention techniques [22].

Disease Risk Prediction Models: Disease risk models use information from various sources, such as genetics, family history, physical activity, and dietary history, among other factors. When all this data is integrated into the AI systems, the various aspects of risk management in a given health center can be effectively profiled based on the individual patients [23]. For instance, based on genomics and life data, AI can diagnose and forecast tendencies to cardiovascular diseases, diabetes or some types of cancers. These models consider genetic risk factors and the patient's environment and lifestyle, showing healthcare providers a 360-degree approach to the patient's health risks [24].

Tailored Preventive Measures: Healthcare providers now have the information that AI can predict the probability that one is at high risk of developing chronic diseases; therefore, prevention measures can be recommended. Such could include changes in dietary practices, mammography, or the use of drugs that would prevent the occurrence of such diseases as heart disease or diabetes [25]. For instance, AI enhances the intake of specific foods, moving more, or getting tested for any health complications by higher-risk individuals. AI improves lifestyles, thus postponing or preventing others from occurring by offering appropriate disease risk readings that suitable interventions can hinder or alleviate the chance of diseases' development [26].

PERSONALIZED TREATMENT RECOMMENDATIONS

Another essential advantage of AI in PM is the possibility of creating personal therapy plans that consider patients' features. This means that with a vast consideration of a patient's genetic and medical history records, AI systems can suggest the best treatments [27]. This application is especially significant in oncology because AI algorithms can consider the genetic mutation of cancer cells to know which treatment works best.

Genetic Mutations and Targeted Treatments: In oncology, AI systems can consider the genetic markers in cancerous cells, allowing optimal treatment choices. For example, by applying artificial intelligence, one can decide whether the tumor is estrogen receptor or HER2 positive, which marks the necessity of using hormonal therapy or target therapy. AI prevents having to guess by suggesting therapies that directly correlate with genetic changes in each tumor, enhancing the overall treatment outcome [28].

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Reducing Side Effects: AI-generated individualized therapies have been shown to reduce side effects usually associated with traditional treatment procedures in medical practice. For instance, chemotherapy and radiation for example make one feel nauseous, experience fatigue and have a low immune system. AI is capable of identifying likely reactions of a patient to these treatments due to their genetics, allowing for selection of other therapies or modification of treatment programs to minimize possible side effects [29]. The procedure guarantees an optimal approach by combining the effectiveness of the treatment plan and its relative tolerability by the patient, which, as a result, improves their quality of life.

MACHINE LEARNING FOR DRUG DISCOVERY

AI is widely present in areas that are important for speeding up the development of individualized treatments, particularly in pharmaceuticals. Using machine learning (ML) algorithms, AI can interpret large sets of medical data on clinical trials, genotyping and the physicochemical characteristics of the drugs under consideration [30]. This speeds up drug 'repurposing', the method of identifying the drugs that might successfully act for each patient, considering the genotype.

Accelerating Drug Development: Using machine learning, the efficacy of a given drug on the genetic profile of a given patient can be predicted, which helps researchers focus on the most effective drug. Machine learning and big data techniques process large volumes of data from clinical trials, genetics data, and pharmacological data to discover potential new therapeutic interventions far more efficiently than conventional approaches [31]. This greatly shortens the cycle of new drug releases to the markets and provides a fast way of finding the right personalized medicine for particular genetic types.

Targeted Drug Combinations in Oncology: In oncology, the suitability of certain medicines for a patient can be determined by an up-to-date computer algorithm based on the genetic changes in the patient's body. Cancer patients' cells may also become resistant to treatment and more challenging to eradicate. AI can look at a genetic change in cancer cells to determine which chemotherapy drugs will be effective [32]. This helps identify specific treatments for certain conditions, diminish ineffective treatment searching, and enhance patient's conditions. For instance, AI technologies can immediately connect patients with EGFR or immune checkpoint inhibitors depending on their tumor's genetics, making cancer therapies more effective [33].

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APPLICATIONS OF AI IN PERSONALIZED MEDICINE

Artificial Intelligence (AI) is already in use in several key areas of precise medicine, including risk assessment and diagnosis, target drug identification, and treatment individualization. These apps are revolutionizing how healthcare is delivered as they lead to more accurate and personalized technique of handling patients depending on their genetic makeup, history and practices [34]. This is seen mostly in oncology, cardiovascular diseases and pharmacogenomics, where AI's capability of analyzing huge volume of data and patterns makes precision health a possibility.

AI in Oncology: Today, AI is revolutionizing the entire sphere of oncology and the approaches to cancer diagnosis and treatment. AI round and macro analysis can run large sets of tumor genetic data to determine which mutations could help treat genes. This is essential for identifying which treatment can benefit a patient's cancer most [35]. For example, the use of AI-enabled the early prediction of the EGFR gene mutation in patients with NSCLC. This identification defines whether specific therapies, such as EGFR inhibitors, should be used to increase the treatment's accuracy and efficacy. It continues to be fascinating to see steady progress in deploying innovations associated with AI in the medical imaging domain. In the past, radiologists identify any irregularities from standard imaging studies MRIs, CT scans, and X-rays [36].

However, AI can help improve the efficiency of such imaging systems by using scans to identify preliminary stages of cancerous tissues or a couple of pixels that human detectives cannot see. For instance, autonomy in a predictive model looks for distinct patterns in imaging to show regions of malignancy that are not yet apparent clinically [37]. Earlier cancer detection is even more critical in increasing survival probability and decreasing the cost of treatment because most cancers are more curable at an early stage than at a later stage. Thanks to engineers' help, oncologists can start changing the treatment paradigm towards individual approaches. AI also assists not only in the diagnosis of the disease in the early stages but also in the choice of further therapy. Regarding a patient's 'RNA sequence', AI is conversant with the specific chemical and immune-therapeutic regimens that will yield the highest prospects of a good result in fighting a particular category of cancer cells without subjecting the patient to side effects [38].

AI in Cardiovascular Disease: The use of AI in cardiology is rising to predict and manage

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cardiovascular diseases involving heart disease, stroke, and arrhythmia. Of the many ways AI has been deployed in cardiovascular medicine, one of the most common is determining an individual patient's risk of developing these diseases based on their genetic makeup and family health history [39]. Adding these factors to lifestyle data that include exercise regime, diet, and history of smoking, among others, AI systems can be used to predict those likely to be affected by heart disease or stroke even before the condition manifests itself. This allows healthcare providers to prevent those risks and to intervene early with education, lifestyle techniques, and medications to decrease the threat of cardiovascular events [40].

For example, when a patient comes to the hospital or clinic, an AI system may evaluate the level of genetic hazard for developing hypertension, diabetes, or atherosclerosis. From the above assessments, AI can suggest the appropriate medication, dietary changes, and the need for follow-up regarding the patient's risk factors [41]. Healthcare providers can provide interventions that may slow or even halt cardiovascular sicknesses to those people viewed as at risk, meaning that the emergence of these sicknesses can be forestalled. AI is also enhancing the timely management of patients with chronic heart conditions. Smart watches and other wearable sensors connected to artificial intelligence can detect multiple cardiovascular parameters, including pulse, blood pressure, and ECG, and alert the patient of his overall state. Such actions may elicit immediate actions, when needed, to alter the affected client's care depending on their current health status [42].

AI in Pharmacogenomics: Another promising area where AI is advancing is pharmacogenomics, the branch of medicine that analyses how genes influence the individual's experience of medications. Bioinformatics is already being employed to determine the interaction between genetic differences and response to drug therapies, as well as the likely reaction of an individual to administered quantities of certain substances [43]. Using genetic information in combination with clinical and pharmacological data gives AI a higher chance to provide more personalized treatments; the drugs administered to the patient will be compatible with their genotype, and thus, the risk of having a bad reaction to the medication will be minimized. For instance, some gene variations interact with the way patient's process drugs [44]. For example, warfarin is an anticoagulant drug, and the genetics of CYP2C9 and VKORC1 may affect the warfarin's metabolism and, therefore, the dose needed for each patient. Bio individuality AI utilizes these genetic differences to calculate the correct dosage to administer, preventing under or over-dosing a patient, some of which have side effects such as

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bleeding or clotting. Pharmacogenomics through AI can also help to generate new drugs by developing them under specific genetic types that would make the drug respond positively. For example, some AI models are being employed to interpret the genetic profiles of cancer patients with a view to identifying which medications are most effective given their mutational profiles [45]. This aids in making sure that patients are served with the right drug therapy with minimal side effects, enhancing precision medicine.

BENEFITS OF AI IN PERSONALIZED MEDICINE

The use of AI makes a significant contribution to the concept of precision medicine in the interest of the welfare of both healthcare professionals and consumers. Such benefits extend beyond the enhancement of treatment practices resulting in early disease identification, reduced expenses, and enhanced diagnosis, which are also aspects of better health [46].

Improved Treatment Outcomes: Therefore, personalized treatment plans employing AI have higher chances of success than conventional treatment methods. To this end, this method makes specific impacts in guaranteeing that patients receive appropriate treatments that meet their individuality. Essentially, expert treatments guarantee better health outcomes for patients than the conventional trial and error methods to identify the best dosage that will treat the ailment while at the same time avoiding the undesirable side effects of the medication. The usage of AI to analyses and compare a variety of data sets means that the treatments delivered are more closely suited to the patient's needs, enhancing the general effectiveness of the therapy given [47].

Early Disease Detection: AI improves the timely diagnosis of diseases by analyzing elaborate genetic and medical information collected early. The use of prediction analysis by AI can detect the lurking biomarkers of diseases such as cancer, diabetes and heart disease. For instance, intelligent models can locate the first signs of cancer, consisting of specific genes and medical image abnormalities, allowing physicians to intervene early when therapeutic approaches are most efficient [48]. It is essential to detect diseases in their preliminary stages, such as cancer or cardiovascular diseases, since early diagnosis largely determines a patient’s perspective prognosis and overall health status.

Transforming Personalized Medicine with Chatgpt and AI: Chatgpt and AI-driven technologies are transforming applications in personalized medicine by combining advanced natural language

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processing with powerful data analytics to deliver tailored healthcare solutions. Chatgpt ability to understand and generate human-like responses enables it to assist in patient triage, provide accessible explanations of medical information, and streamline communication between patients and healthcare providers. When integrated with AI models for personalized medicine, these systems can analyze patient histories, genomics, and biomarkers to predict disease risks, recommend targeted therapies, and optimize treatment plans. Together, these innovations are creating a more interactive, precise, and patient-centered approach to healthcare, enhancing outcomes while reducing costs [49].

CHALLENGES IN THE IMPLEMENTATION OF AI IN PERSONALIZED MEDICINE

The application of AI in the field of personalized medicine is promising, though to unlock it several issues must be solved of great importance.

Data Privacy and Security: Collection and processing of huge amount of patient data, including genetic data, makes the issues of data privacy and security critical for the functioning of AI systems. Real-world business entities dealing with patients' information are required by law to adhere to certain regulations, including HIPAA and GDPR, to minimize the risk of information leakage, breaches or misuse [50]. This is the case since patients not only have to be guaranteed that patient information will remain secure, with encryption to keep third parties out from accessing the details, it is also crucial that the systems are legal compliant.

Algorithmic Bias: It means that any AI model can only be as accurate as the dataset fed into it. If the datasets used in the training of such models are flawed in any way, including being incomplete or biased in some way, then the result produced by the AI system will be flawed in the same way. They force the health disparities to increase and result in misdiagnosis, especially if some communities are excluded from the data model. Addressing the issues of data imbalance is essential when using AI models to achieve fair treatment for all patients since selection bias is a primary concern [51].

Integration with Existing Healthcare Systems: AI implementation requires marketers to consider opportunities within and across existing healthcare structures. Most healthcare institutions still rely on archaic technology, which poses a challenge when implementing AI in day-to-day work. For AI to be properly used in any healthcare organization, it requires purchasing new technologies, modifying the process of care delivery, and educating the healthcare workforce on how to fully use artificial intelligence. Further, AI systems must integrate with EHRs and other CDS systems with which

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clinicians actively collaborate in the care process [52].

THE FUTURE OF AI IN PERSONALIZED MEDICINE

The prospects of integrating AI knowledge in upcoming personalized medication are enormous. With the advancement of machine learning and deep learning, AI will likely diagnose diseases further accurately, detect diseases in their initial stage and suggest treatments tailored to the individual patient's needs in the future [53]. Additionally, AI will continue to have significant applications in extending worldwide access to personalized medicine, promoting that areas with limited healthcare personnel can access remote health checks and diagnostics tools. With further development of AI technologies, the given technologies will open one more level of healthcare's potential for delivering the highest level of personalized, cost-effective, and efficient healthcare solutions to the population and making healthcare more easily accessible and offered individually [54].

CONCLUSION

The continuing development will influence the integration of ESG factors in the future of healthcare in technology, changes in the existing ESG regulations and the increasing pressure for measurable outcomes. New technological tools will help organizations address data collection and green washing problems and improve the accuracy and efficiency of their processes. Healthcare is expected to become more sustainable and equitable because of regulatory requirements and consumer demands, thus continuing the increase of ESG concerns. However, stakeholder cooperation, technological advancement, and sustained efforts are necessary to realize these objectives.

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