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Narrative Review

A NARRATIVE REVIEW OF PRECISION MEDICINE, ARTIFICIAL INTELLIGENCE, AND THE FUTURE OF PERSONALIZED CARE: REVOLUTIONIZING HEALTHCARE.

S.K. Prasad*
*Assistant Professor, Department of Medicine, Darbhanga Medical College Hospital, Darbhanga, Bihar, India.

ABSTRACT

Background
The merging of AI and precision medicine is a paradigm change in healthcare. Precision medicine uses patient-specific traits to adapt medical interventions, while AI improves decision-making with advanced computational approaches. This convergence considers genetic and nongenomic characteristics, patient symptoms, clinical history, and lifestyle to address precision medicine difficulties.

Objective
This narrative review explores the potential of AI in advancing precision medicine. It examines the synergy between AI and precision medicine, emphasizing their combined capacity to enable individualized diagnosis and prognosis for patients with unique healthcare requirements or atypical responses to treatments.

Summary of Narrative Review
Recent literature underscores the promise of AI in precision medicine through translational research. AI's computational power allows it to analyze vast datasets, identify patterns, and generate valuable insights. By integrating genomic and nongenomic determinants with clinical and lifestyle data, AI enhances the accuracy and effectiveness of diagnosis and prognosis. This review delves into the transformative potential of this convergence, highlighting its applications in healthcare decision-making and patient care.

Implications for Future Research
Future research should focus on further developing AI-driven precision medicine tools and platforms. Investigating the real-world clinical impact of AI-driven precision medicine is essential, along with evaluating the scalability, ethical considerations, and regulatory frameworks for its implementation. Additionally, exploring AI's potential in optimizing treatment plans, drug discovery, and healthcare resource allocation is a crucial avenue for future research.

Clinical Practice and Policy Development
The amalgamation of AI and precision medicine offers healthcare professionals augmented intelligence, empowering them to make more informed decisions tailored to individual patient needs. This has the potential to improve treatment outcomes, reduce adverse effects, and enhance patient care. Policymakers and healthcare institutions should consider investing in AI-driven precision medicine initiatives and establishing guidelines for data privacy, ethics, and patient consent to ensure its responsible and ethical implementation.

Keywords: *Artificial Intelligence, Precision Medicine, Healthcare Transformation, Augmented Intelligence, Translational Research, Genomic Determinants.*
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Corresponding author: S.K. Prasad*
Email: drvinaysk84@gmail.com
*Assistant Professor, Department of Medicine, Darbhanga Medical College Hospital, Darbhanga, Bihar, India.

INTRODUCTION

The National Academy of Medicine recently released a report on artificial intelligence (AI) in healthcare, in which the authors stressed AI's promising potential to support medical practitioners and overcome human limitations including exhaustion and inattention [1]. They emphasized the necessity of AI to support human endeavors and the significance of openness and confidence in AI systems.

Rapid technical breakthroughs and the digitization of health-related data are driving the importance of AI in healthcare. But there are issues that must be resolved, including bias, data integration, security, and model performance [2].

Three guiding concepts are necessary for the successful application of AI in healthcare: shared expertise, analytics and insights, and data and security. AI systems must be

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trusted, and rather than taking the place of human decision-making, AI should improve it.

Individuals produce a huge quantity of data, and this data can have a big impact on health since it includes behavioral, environmental, and hereditary components. The characteristics of this big data phenomenon are volume, pace, variety, authenticity, and worth. The increased accessibility of technology thanks to mobile devices has increased demand for interactive data analysis tools.

Applications for AI and big data analytics can be found in the healthcare industry for payers, providers, legislators, patients, and product manufacturers. They can assist healthcare policies, enhance clinical decision support, and help avoid fraud. AI, for instance, can forecast patient readmissions and identify billing problems.

Another significant area of study is precision medicine, which seeks to tailor treatment based on patient information. Access to large datasets and a healthcare system ready to implement customized plans are prerequisites for this strategy. Healthcare could be revolutionized by the combination of AI and precision medicine.

The capabilities of AI, the development of precision medicine, and practical examples showcasing AI's revolutionary potential to advance precision medicine will all be covered in the parts that follow.

The review topic raises several key questions that underpin the exploration of the role of artificial intelligence (AI) in healthcare. First and foremost, it seeks to understand how AI can effectively support medical practitioners and address inherent human limitations, such as exhaustion and inattention, emphasizing the need for AI to augment human endeavors. Additionally, the review delves into the challenges and issues surrounding AI implementation in healthcare, including concerns related to bias, data integration, security, and model performance, with a focus on identifying potential solutions. Furthermore, the review examines the diverse applications of AI and big data analytics across various healthcare sectors, ranging from payers and providers to legislators, patients, and product manufacturers, highlighting their roles in enhancing healthcare policies, clinical decision support, and fraud prevention. Lastly, the review explores the transformative potential of the convergence of AI and precision medicine, emphasizing its capacity to revolutionize healthcare by tailoring treatment based on patient information and leveraging extensive datasets for data-driven insights. These key questions provide a comprehensive framework for the comprehensive analysis of AI's impact on the healthcare landscape.

METHODOLOGY

This narrative review searched PubMed, MEDLINE, and pertinent academic journals for relevant articles, studies, and reviews published between 2015 and 2022. For the review, terms like "artificial intelligence," "precision medicine," "healthcare," "AI in healthcare," "precision medicine applications," "genomic data," and related topics were searched. Studies and papers on AI and precision medicine in healthcare were searched. This study includes articles that examined AI and precision medicine integration, applications, problems, and future possibilities, and provided significant insights. Not directly connected to AI-precision medicine convergence or published outside the defined timeframe were eliminated. The selected articles were examined for AI applications in precision medicine, obstacles, and developing synergies. Key findings, methodologies, and examples of AI-driven precision medicine applications were summarized.

ARTIFICIAL INTELLIGENCE

AI has become widely accepted in many industries over the last ten years, including healthcare. It provides chances to develop new business models, creative services, and intelligent goods. But the application of AI also brings up moral and societal issues with regard to privacy, security, and human rights.

AI technology is used in medicine in a variety of ways, from cyber-physical applications like drug delivery via tailored nanorobots to virtual systems like deep learning-based health information management. In healthcare, image-based detection and diagnosis systems have been made possible by AI, which may sometimes outperform humans in identifying intricate patterns and hidden structures. Clinical decision support systems powered by AI can improve decision-making, lower diagnostic mistake rates, and help with activities like data extraction from electronic health records [3].

The increasing processing power of AI has raised worries about the possible replacement of medical professionals. A better phrase to use would be "augmented intelligence," which highlights the partnership between data, computing, and healthcare providers, rather than replacing them.

The four main traits of cognitive AI systems are comprehension, reasoning, learning, and empowerment [4]. Large volumes of both structured and unstructured data are understood and processed by them; they reason by establishing connections and deductions; they gain knowledge from professionals and real-world examples; and they engage and empower people by providing insights that can be put to use. Humans, on the other hand, are superior in traits like morality, empathy, inventiveness, and common sense.

AI-enhanced human capabilities yield useful insights in primary care, imaging, and oncology, among other medical fields. An algorithm that has been trained using electronic health data and mammography pictures, for instance, can predict the malignancy of breast cancer and enhance early

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detection, potentially lowering the number of missed diagnoses.

AI is a useful tool in the medical area since it improves patient care and diagnosis when used in conjunction with healthcare personnel.

PRECISION MEDICINE

The rapidly expanding discipline of precision medicine is dedicated to providing personalized healthcare to individuals based on their specific features, such as genetics, medical history, behavior, and environment. It developed from the basic concept of using molecular biology to create a new taxonomy of diseases, which was inspired by the sequencing of the human genome [5]. In order to precisely describe health and disease states and create individualized treatment options, precision medicine integrates data from multiple sources.

With this method, medical professionals are empowered to make choices based on the unique characteristics of each patient rather than on data that is generalized to the majority of patients. Precision medicine has a big impact on healthcare since it can identify illnesses early and create individualized therapies. Precision medicine is made possible by technologies that facilitate data collection and analysis, such as genotyping and electronic health records.

Genotype-guided treatment is a well-known use of precision medicine in which genetic data is used to recommend the right course of treatment or dosage of medication. For instance, genomic analysis of tumors informs targeted therapy for cancer patients, and genotyping helps optimize the dosage of warfarin. Customized treatment plans may be created, illness risk can be predicted before symptoms manifest, and diagnostics can be improved with precision medicine [6].

Initiatives like Biobanks in different nations, like the UK Biobank, BioBank Japan, and the Australian Genomics Health Alliance, are contributing to the global advancement of this discipline [7]. There are still issues to be resolved, such as the requirement for standardized data formats, availability to high-quality labeled data for AI algorithm training, and taking social, privacy, and legal issues into account.

FUTURE SYNERGIES BETWEEN AI AND PRECISION MEDICINE

Pharmacogenomic Insights in Therapy Planning: Tailoring Prescriptions and Dosages for Patients with Actionable Genetic Variants.

Precision medicine has a big component called genome-based prescribing. Machine learning algorithms is needed to forecast which patients, based on their genomic data, would need a certain treatment in order to provide appropriate recommendations. It is essential to genotype these patients beforehand in order to properly customize dosages and treatments. Early precision medicine applications of AI integrated genome interpretation with AI to provide new insights into the relationships between genetic variants, illness features, response to treatment, and prognosis [8].

Different molecular subgroups of medulloblastoma were identified using AI analysis of many exomes. This discovery made it possible to treat and dose a specific subset of pediatric patients appropriately. Precision genomics made it possible to treat the "wingless" tumor subgroup, which is more prevalent in youngsters, with chemotherapy alone as opposed to the conventional combination of surgery, chemotherapy, and whole-brain radiation [9]. For cancer survivors, avoiding radiation is especially helpful in lowering the risk of neurocognitive adverse effects and subsequent malignancies.

Radiogenomics is a result of AI's success with picture recognition. In order to forecast the likelihood of post-radiotherapy damage, this developing field focuses on making links between gene expression and cancer imaging characteristics. AI has been used to identify radiogenomic associations in a variety of cancers, including colorectal, liver, and breast cancer, as well as to predict the isocitrate dehydrogenase genotype in gliomas. Limited data accessibility is still a major obstacle in AI radiogenomics, though.

Planning a patient's course of therapy requires an understanding of their response to it. Potential uses of AI in this field include the prediction of chemotherapy response in patients based on gene expression data. AI is also able to recognize patterns in gene sequences linked to improved results from non-traditional treatments. Even though there has been a lot of improvement, additional investigation and clinical trials are necessary to produce the data needed to properly train these algorithms.

Considering Environmental Factors in Treatment Planning: Equitable Access to Quality Care Regardless of Zip Code.

Having sufficient knowledge about a patient's personal and environmental circumstances is necessary to incorporate environmental aspects into treatment programs. A patient's chance of a poor outcome, their understanding of various treatment options, and the circumstances under which each option is most effective can all be affected by this information.

For example, think about how difficult it might be to determine whether a patient is homeless. These patients' personal information needs to be updated often because they can require care in several locations in a short period of time. It is also necessary to consider other environmental aspects, such as transportation, the provision of cold-requiring medications, or the use of electrically powered diagnostic gear.

The accessibility of medical knowledge in isolated locations is another environmental factor to be taken into account. AI has demonstrated how it can improve diagnostic capabilities in resource-constrained environments. This may result in more accurate patient classification and, as a result, more customized treatment strategies [10]. AI has been used, for example, to monitor allergen levels, forecast infectious disease outbreaks, identify people with diseases like malaria and cervical cancer, and assess exposure to environmental contaminants.

Clinical factors in treatment planning: Co-existing medical conditions are always a factor, and AI can help with risk assessment

In addition to genetic and social factors, clinical considerations are essential for treatment planning to be successful. Treatment decisions are based on factors including age, pre-existing medical disorders, and organ function. AI is essential in classifying patients for appropriate medicines. In one study effort, for example, machine learning classifiers assessed thirty coexisting disorders to determine which patients were critically ill and would require tracheostomy installation and prolonged mechanical breathing [11]. AI algorithms have been used in other research to evaluate adverse events that are tracked at the bedside and different clinical indications that predict organ failure and malfunction.

Genomic factors in risk assessment or diagnosis: Individuals with confirmed genetic risk for a disease might require distinct preventive healthcare approaches.

The response of actress Angelina Jolie after learning she inherited the BRCA gene highlights the potential influence of modern genomic information on illness risk and preventive measures [12]. This is not an isolated incident; a similar healthcare conundrum was raised by Woodie Guthrie's condition and Huntington's sickness [13]. Personalized prevention and management of major diseases is now possible thanks to the broad availability of genetic information through next-generation sequencing and direct-to-consumer testing, while ethical concerns around genetic testing in the absence of a known cure are still being debated.

Predictive models have long been used to evaluate patient risk in the field of cardiovascular medicine. Methods to predict heart failure and other cardiac problems in asymptomatic persons have been established by recent study. These models can improve the incidence and consequences of disease when paired with tailored preventative approaches. Gender, genetics, lifestyle, and environment all play a role in the development of complex disorders like cardiovascular disease. Taking into account the diversity of the data is necessary for integrating various factors.

AI techniques are highly effective in revealing intricate connections between a multitude of variables, presenting advantageous prospects. In an early example of merging genetic data with electronic health records (EHR), Vanderbilt University [14] conducted a study that showed promising results in the prediction of cardiovascular disease. The identification of genetic variants in pictures or EHRs that enable AI-enabled phenotypic feature detection can speed up the diagnosis of genetic diseases. For example, fast whole-genome sequencing and automated phenotyping with NLP support can provide precise and timely diagnoses for critically unwell newborns suspected of having a genetic disorder.

Non-genetic factors in risk assessment or diagnosis: Individuals with changes in speech or walking patterns may be prone to depression.

Technological developments in Natural Language Processing (NLP) have led to improvements in automated speech analytics. This technique can provide hints for diagnosing and identifying mental diseases such as Parkinson's disease, mild cognitive impairment, early-stage dementia, and others [15]. Attempts are also under progress to use smartphone sensors to track changes in mental health. In order to minimize difficulties and stillbirths, AI-assisted monitoring can be utilized in real-time to evaluate the risk of intrapartum stress during labor and assist in making the decision between a vaginal delivery and a cesarean section. This is an example of real-time data monitoring supported by AI to minimize human mistake in the interpretation of cardiotocography data during labor.

AI is also being used during colonoscopies to identify and classify polyps [16]. Expanding the use of AI in endoscopy could reduce expenses and the likelihood of needless polypectomies while also improving the identification rate of benign adenomas. It's likely that AI-based picture analysis will be utilized in the future to identify diseases like benign melanoma, metastasis from malignancy, and diabetic retinopathy. Another component of a direct-to-consumer anemia diagnostic solution is AI-driven image analysis.

It has long been anticipated that wearable technology and home monitoring would aid in the early detection of illness. These developments have resulted in noninvasive wearable applications for diabetes, epilepsy, pain management, Parkinson's disease, heart disease, sleep disorders, and obesity, among other health concerns. Digital biomarkers are anticipated to facilitate decentralized clinical trials and provide remote disease monitoring beyond hospital walls. In the context of cancer care, wearable technology that continuously examines circulating tumor cells to screen for disease relapse is especially useful. These technologies can detect minor residual illness and track the evolution of the disease.

ONGOING CHALLENGES USING AI IN PRECISION MEDICINE.

AI is being used more and more in precision medicine to help with things like therapy response, risk assessment, and illness diagnosis. Even if a lot of research has produced encouraging findings, it is still necessary to show how AI may actually enhance healthcare. Accuracy is simply one factor in the success of using AI in real-world healthcare; other factors include dependability, safety, and flexibility.

The following three primary obstacles may prevent AI from being successfully applied in the real world of healthcare:

1. *Fairness and bias*: When creating and processing datasets, health data may contain biases that are not intended, which might cause bias in AI models. Due to this bias, some groups of people may be given less favorable treatment when making judgments because of their age, gender, race, location, or socioeconomic standing. It's critical to identify and reduce bias in both data and models in order to meet this problem; this may be done by increasing data variety and using AI techniques to counteract bias.
2. *Socio-environmental factors*: The clinical efficacy and performance of AI models can be influenced by the processes and environment in which they are used. The necessity of verifying AI models in real healthcare settings is underscored by prospective studies that have shown difficulties in integrating AI systems in genuine clinical settings [17]. Prior to widespread use, user feedback must be gathered and incremental changes must be made.
3. *Data privacy and safety*: Trust in AI-enabled services is strongly correlated with data privacy concerns. More information will be gathered and combined as AI and precision medicine become more similar. This information will include genetics, medical history, behaviors, and social data. It is imperative to establish a safe ecosystem encompassing new technologies, partnerships, laws, and economic models for the storage, management, and exchange of data.

In a nutshell resolving these issues will contribute to the effective incorporation of AI into precision medicine. In the pursuit of individualized healthcare, it is critical to test AI models in actual clinical settings, reduce bias, and give data security and privacy top priority. Additionally, wearables, smartphone apps, and other intelligent systems have the ability to put consumers' hands on technology and help with tailored care and behavior modification.

DISCUSSION

The review underscores the transformative potential of combining artificial intelligence (AI) and precision medicine in healthcare. AI's augmented intelligence can greatly benefit clinical practice by enabling informed and personalized decision-making, improving disease diagnosis, treatment prediction, and identification of environmental influences on patient outcomes. This integration promises enhanced patient care and reduced diagnostic errors.

In terms of policy, addressing fairness, bias, data privacy, and socio-environmental factors is crucial for ethical and equitable AI-driven precision medicine implementation. Policymakers must establish frameworks to ensure responsible AI use, protect patient data, and promote accessibility for diverse populations. Real-world validation of AI models and ongoing user feedback collection are essential.

Future research should focus on refining AI algorithms, expanding data sources, conducting clinical trials, and addressing bias and data privacy concerns. The synergy of AI and precision medicine holds the potential for revolutionary improvements in healthcare, offering accurate diagnoses, targeted treatments, and enhanced patient outcomes. Collaboration among healthcare professionals, policymakers, researchers, and technologists is essential for realizing this potential.

CONCLUSION

Ongoing investigations in the fields of artificial intelligence (AI) and precision medicine are revealing a forthcoming era in which the responsibilities pertaining to health-related matters, undertaken by both medical practitioners and individuals seeking medical assistance, will be enhanced through the utilization of exceedingly tailored medical diagnostic and therapeutic data. The convergence of these two influential factors and their implications on the healthcare system are in accordance with the overarching objective of disease prevention and timely identification of ailments afflicting individuals, thereby potentially mitigating the overall disease burden on the general population and consequently reducing the expenses associated with avoidable healthcare services for the entire populace.

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List of abbreviations

AI- Artificial intelligence
EHR- Electronic health records
NLP- Natural Language Processing

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Conflict of interest

The authors have no competing interests to declare.

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