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Review Article

From algorithm to applications: Artificial intelligence – A future prospective in medicine

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ABSTRACT

Background: Artificial intelligence (AI) is a boon to the human race that offers transformative potential in the medical care system, revolutionizing human well-being. Over the past five decades, AI has evolved significantly in deep learning and machine learning (ML). AI subfields work together to provide intelligence for various applications. ML is a self-learning system that can improve its performance through training experiences. Utilizing artificial neural networks mimics human brain functions, while computer vision involves computers extracting information from images or videos. The application of AI is deployed across diverse medical fields, including cardiology, dermatology, ophthalmology, and oncology, enhancing diagnostic procedures and treatment outcomes.

Objective: This review aims to explore current trends of AI in healthcare, evaluate its impact across different medical fields, and identify future prospects for AI-driven innovations in personalized medicine and beyond.

Method: A comprehensive literature analysis was undertaken using prominent databases such as "PubMed," "Scopus," and "Google Scholar."

Results: The review found that AI has significantly impacted multiple areas of healthcare. In diagnostics, AI applications have improved accuracy and efficiency, particularly in fields such as cardiology and oncology. Overall, while AI holds promise for revolutionizing healthcare, its success will depend on addressing the challenges and continuing to advance both technology and implementation practices.

Keywords: Artificial intelligence in healthcare, Artificial intelligence in medicine, Artificial intelligence technology, Artificial intelligence, Current trends in artificial intelligence

INTRODUCTION

Artificial intelligence (AI)

AI is described as "a field of science and engineering concerned with the computational understanding of what is commonly called intelligent behavior, and with the creation of artifacts that exhibit such behavior."[1] During the 1950s, Alan Turning pioneered a foundational role in shaping AI and current-generation technology. This concept, famously known as the "Turning test."[2] John McCarthy first employed the term "Artificial Intelligence" in 1956 at the Dartmouth Conference, which is regarded as the beginning of the research of AI.[3] Early AI research concentrated on symbolic approaches and problem-solving strategies but was constrained by computing limitations and the intricacy of human thought.[4,5] A major turning point was the introduction of machine learning (ML), especially through artificial neural networks (ANNs) in the 1980s, which allowed machines to learn from data and get better on their own. Advances in computing power, data accessibility, and algorithms have sped up this process in the 21st century, resulting in the broad use of AI in industries including healthcare, finance, and transportation. AI is now transforming diagnosis and workflow efficiency in the medical field by enabling self-learning systems and processing complex data.[6,7]

Over the past five decades, AI has evolved significantly in deep learning (DL) and ML. AI subfields work together to provide intelligence for various applications. ML has evolved into DL, which includes ANNs that replicate human cognitive processes. Simultaneously, computer vision involves computers extracting information from images or videos.[8] The implementation of AI plays a key role in Dermatology,[9] Ophthalmology,[10] Cardiology,[11] and Oncology[12] and various medical fields. AI has a wider application in medicine

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by enabling personalized drugs through predictive models for disease diagnosis, therapeutic response prediction, and future prospects in preventive medicines.[13] In this article review, we delve into the present use of AI across the different practices of medicine and examine its future prospects for enhancing its multifaceted impact on the healthcare system.

Types of AI

AI in the medical field consists of various types, and each can potentially perform different distinct functions that promote healthcare services. Mainly these are classified into two types based on the nature of the AI's interaction with the physical world. They are as follows:

- Virtual AI
- Physical AI.

Virtual AI works in digital settings, processing and evaluating medical imaging, electronic health records (EHRs), and other digital data to enhance clinical judgment, increase the precision of diagnoses, and personalize treatment regimens. For example, a computational anthropomorphic phantom AI model can conduct virtual clinical trials, offering an efficient methodological alternative for evaluating and optimizing imaging concepts and technologies.[14] Besides clinical trials, virtual AI is essential for patient compliance and engagement. Chatbots and virtual assistants driven by AI give patients timely information, medication adherence reminders, and advice on how to manage chronic illnesses. The overall quality of care is improved by this ongoing interaction, which encourages a more interactive dynamic between patients and healthcare professionals.[15,16] In contrast, physical AI includes the integration of physical devices or robots in the surgical practice.[17] Using tele-manipulators or computer-controlled devices, robotically assisted minimally invasive surgery enables remote operations. Devices such as the da Vinci Surgical System and the Six-axis robot improve accuracy and adaptability.[18] This technology is particularly useful in delicate surgeries such as cataract procedures in ophthalmology.[19,20] In addition, wearable physical AI sensors can provide real-time monitoring of various health parameters and offer a real-time solution for conditions such as Parkinson's disease, diabetes, and stress.[21] The main distinctions between virtual and physical AI are illustrated in Table 1.[22,23]

CURRENT TRENDS OF AI IN HEALTHCARE

Current trends underscore the numerous applications of AI technologies, such as ML, natural language processing, and predictive analytics, which collectively enhance operational efficiencies and improve health outcomes.[24,25] The following are the current applications of AI in healthcare,

- Improved and predictive diagnosis[26]
- Effective drug discovery and clinical trials[27,28]
- Optimizing treatment plans and their outcomes[28]
- Automate routine tasks in hospital settings[29]
- Identification of drug-related problems and their adverse drug reactions[30]
- Management of chronic conditions using AI wearables[31]
- Improves teleconsultation with virtual assistants gathering patient data and offering insights[32]
- Enhances precision in minimally invasive surgeries with AI-guided robotic systems[33]
- Assists in diagnosing and managing mental health conditions using AI-powered tools.[34]

AI in pharmaceutical research

Drug discovery and development is a complex procedure that involves a multidisciplinary journey and confronts challenges despite biological insights, cost, and time investment.[35] ML is a Potent AI technology, notably propelled ANN, and recurrent neutral network,excellent in learning and predicting novel properties.[36] In the National Institutes of Health "Toxicology in the 21st century" (Tox21) challenge study, Mayr *et al.* demonstrated that deep neutral networks outperformed baseline ML methods, highlighting enhanced predictive in toxicity assessment. The efficiency of ML in predicting property hinges on the pivotal access to large datasets, which is especially important in the pharmaceutical industry. Diverse datasets across various chemical series systematically enhance

Table 1: The difference between virtual AI and physical AI.

Virtual AI	Physical AI
• Virtual AI is used to process and analyze data in the digital form.	• Physical AI is integrated into physical devices or robots that interact with the physical environment.
• The core functions of virtual AI include analyzing data, enhancing workflow, supporting decision-making, and providing predictive analytics.	• The core function includes performing physical tasks such as surgery, caregiving or patient interaction.
• These are used in supporting healthcare decisions diagnostic assistance, patient data management and predictive analytics.	• These are used in elderly care, robotic surgeries, rehabilitation, procedures and surgical assistance.
• For example: Data analysis platforms, AI-driven diagnostic tools and virtual assistants.	• For example: Robotic surgery systems such as Da Vinci robotic surgery system, robotic prosthetics and rehabilitation robots.

AI: Artificial intelligence

ML models, shaping the future of compound optimization in the pharmaceutical sector.[37]

ML transforms chemo-informatics using mathematical analysis of chemical graphs to provide a variety of 2D/3D descriptors. The fusion of large databases and machine learning, which incorporates information ranging from the atomic scale to the whole organism level. It is vital for developing safer drugs, while the evolution of DL networks offers promising efficiency in learning from a large database for developing new drug products.[38] AI facilitates the investigation of emerging anticancer targets and drug discovery through diverse algorithms, encompassing network-based and ML-based biology analyses.[39] ML, DL, and neutral network technologies prove valuable not only in identifying cancer targets but also in discerning genotypes and phenotypes across diverse cardiovascular diseases and contributing significant advancements in reproductive medicine.[40,41]

AI in diagnosis

The current trend in medicine focuses on making use of AI for diagnostic applications. When a medical practitioner employs AI to assist in diagnosing a patient's specific illness/condition, there is an improvement in early diagnosis, contributing to the prevention of life. AI analyses the data from pathology, radiology, and ultrasonography and provides accurate diagnosis within a short duration of time. It expeditiously resolves issues, enabling healthcare professionals to provide deliberate and rational treatments for specific diseased conditions.[42] Radiology is vital for diagnosing diseases, but the rising demand exceeds the slow increase in skilled professionals, causing pressure and misdiagnoses. The implementation of AI in radiology has become crucial, filling gaps in medical expertise and provide advanced healthcare. For example, Heydon *et al*. conducted a prospective analysis of an AI-enabled algorithm to screen 30,000 diabetic retinopathy patients. The DL program demonstrated rapid detection, especially when assessing large samples where trained personnel are scarce.[43] In addition, Stoel research highlights the role of DL in the specific clinical task, especially in imaging for early detection of rheumatoid arthritis.[44] During the recent pandemic, researchers rapidly leveraged AI to identify COVID-19 patients using demographic, medical, and public health data. This technology is also beneficial in addressing rare diseases (RDs) or orphan diseases, enabling quicker and more efficient diagnoses. The combination of brain function and structural imaging data can predict the chance of individuals getting Huntington's disease within a given timeframe. These examples highlight the promising capable of AI in the early identification of RDs.[45,46] For instance, Mei *et al*. developed a model that demonstrates its capability as an accurate AI model for prompt detection of COVID-19 patients.[47] AI robots are essential in the field of medical imaging, as they analyze vast datasets to accurately identify abnormalities, such as tumors in radiological images.[48,49] A study by Duan *et al*. explored a 5G-powered robot-assisted tele-ultrasound diagnostic system for critical care. The robotic arm enables remote ultrasound examinations, addressing challenges in high-risk and resource-constrained settings while ensuring high image quality, safety, and diagnostic consistency.[49]

AI in cardiology

Cardiologists often view AI as more of a visionary concept rather than acknowledging its transformative role in medicine, especially in cardiovascular care. AI minimizes human errors and protects patients from invasive procedures. AI holds promise for the future of patient care as civil organizations are currently employing AI technology in health care applications. The ML protocol can be used in many clinical data such as electrocardiogram and echocardiogram to anticipate outcomes. The multi-ethnic study of atherosclerosis experiment is a population-dependent survey that certifies ML proves effective in foretelling the risk. Deep phenotyping with markers imaging unfolds crucial for cardiovascular event prediction. At present, there is a trend toward developing microbots for targeted drug delivery within the body, which represents a futuristic application of AI in disease treatment.[50] The findings from the CEREBRIA-1 (Machine Learning vs Expert Human Opinion to Determine Physiologically Optimized Coronary Revascularization Strategies) trial showed that a ML algorithm analyzing instant wave-free period traces performed on par with expert opinions in determining optimal percutaneous coronary intervention (PCI) strategies for stable computer-aided detection (CAD) patients.[51]

In Ambale-Venkatesh *et al.* study, encompassing 6814 participants, random forests demonstrated effective cardiovascular risk prediction over 11.2 years, identifying 831 deaths and 710 affected by cardiovascular events such as heart attack and stroke. Key predictors such as inflammation and subclinical atherosclerosis provide valuable insights, creating a strong foundation for utilizing huge data in risk prediction and in identifying the biomarker. This study underscores the significance of data-driven hypotheses in cardiovascular research.[52] On the other hand, robotic cardiac surgery enhances limited invasive procedures with improved dexterity, tremor-free movements, superior visualization, and successful execution of complex operations such as mitral valve repairs and coronary revascularization.[53] A study in university affiliated hospital revels robotic-assisted cardiac surgery (RACS) using the Da Vinci system, highlighting its efficacy and safety compared to traditional open-heart surgery. The findings indicate shorter intensive care unit stays and quicker recovery times for patients undergoing RACS.[54]

AI in dermatology

The implementation of AI in dermatology initially focused on melanoma but has recently been widely applied to a broad range of diagnostic applications and treatment strategies. Convolutional neural network (CNN) is, the leading DL algorithm for imaging diagnosis, various studies have achieved a dermatological classification of dermatofibroma from dermatological imaging methods.[55,56] In dermatology, computational methods are increasingly used to speed up the data processing that leads to accurate and reliable diagnosis.[57] In 1987, the TEGUMENT14 system was introduced for personal computers to assist with dermatopathology. It achieved a diagnostic accuracy of 91.8% in identifying 986 histopathological conditions from light microscopic images, matching the performance of a qualified dermatopathologist.[58] Tracking atopic dermatitis over time with measurements is important for checking patient progress and how well treatments work. However, it can take a lot of time and the results can vary between different people doing the rating. The two main indexes used for evaluating the severity of atopic dermatitis are the eczema area and severity index and the Severity Scoring of Atopic Dermatitis Index, both of which have been shown to accurately assess the severity in in-person evaluations.[59] Digital health devices and other medical strategies can significantly enhance and transform the treatment process. Their unique capabilities make them crucial in modern healthcare. Healthcare providers and patients can utilize this tool to train and monitor them, supporting the maintenance of an outpatient treatment program. Dermatologists with over 5 years of experience strongly advocated for incorporating AI into dermatology residency training ($P = 0.001$) and showed greater enthusiasm for AI.[60] In contemporary society, biosensors are integral to biomedical diagnostics, with multifaceted uses in clinical practice and biomedical research. They offer valuable insights into skin health and diseases by enabling the early detection of specific biomarkers associated with various skin conditions. This early identification facilitates prompt and effective interventions.[61] Dermatologists can use these sensors to collect current data, enabling early detection and treatment of conditions like melanoma, improving therapeutic outcomes, and potentially saving lives.[62] Huang *et al.* recently released two studies examining the medical expertise of OpenAI's ChatGPT, a popular large language framework, in diagnosing systemic lupus erythematosus and psoriasis. The researchers posed 14 typical questions to the system and reviewed the responses using specialist assessments and readability metrics. While the researchers' intent to assess these developing innovations was commendable, studies have significant weaknesses. This correspondence aims to highlight these vulnerabilities and offer suggestions for improving subsequent research on the clinical understanding of large language models in dermatological disorders.[63,64] Despite rapid advancements in dermatological AI, its clinical application faces significant challenges. In the beginning, the quantity of imaging data for skin diseases is still insufficient. The situation is further complicated by the limited level of information exchange throughout hospitals and inconsistent standards and quality of skin pictures. The difficulty in obtaining high-quality image data undermines the reliability of research outcomes, highlighting an urgent need for improvement in these areas.[65]

AI has shown significant potential in dermatologic malignancies, especially in recognizing the difference between benign moles and carcinoma. These algorithms analyze skin lesion images to the pixel level so researchers can predict and classify malignancies with high accuracy. Numerous landmark studies highlight the high sensitivity and specificity of AI in identifying malignant versus benign lesions. For instance, Esteva *et al*. developed a CNN on a massive dataset of over 100,000 biopsy-verified clinical imaging reports to differentiate between keratinocyte cancer and Seborrheic warts, as well as between malignant carcinoma and benign moles.[66] similarly, Han *et al*. refined a CNN model to classify various melanoma, including its subtypes, while ML is also enhancing dermatopathology by classifying tumors in digitized histology slides.[67] Woźniacka *et al*. employed CNNs to aid in histopathologic melanoma diagnoses, while other research has used indirect immunofluorescence microscopy to classify linear immunoglobulin A disease, reflecting the growing integration of emerging technologies in dermatology.[68] It is crucial to determine the specific conditions under which AI algorithms can effectively contribute to clinical practice in this field. Collaborative efforts between humans and machines have shown encouraging outcomes, paving the way for future applications. This positive synergy has the potential to improve diagnostic precision, refine treatment decisions, and enhance procedure outcomes in dermatological care.[68,69]

AI in ophthalmology

The integration of DL and ML has revolutionized treatments in ophthalmological practice. There have been notable strides in managing retinal diseases. For instance, an AI-powered device has gained Food and drug administration (FDA) approval for diagnosing diabetic retinopathy. Moreover, a DL system has been engineered to independently detect and quantify retinal fluids in the eye.[70] "AI" systems are currently being researched and developed for a variety of diagnostic applications. They include diagnosing and grading cataracts in pediatric patients through slit-lamp image analysis, detecting glaucoma by measuring retinal nerve fiber layer density and optic fields, and diagnosing conical cornea using Corvis ST tonometry.[71,72] Efforts are underway to develop approaches for the early diagnosis and treatment, especially in regions with limited access to medical care.[73,74] ML and DL can automatically detect fluid drusen, enabling the downstaging of age-related macular degeneration. AI-based applications have shown enhanced sensitivity and specificity, which results in improved diagnosis and treatment through early detection.[75,76]

Using optical coherence tomography scans, Gulshan *et al*. diagnosed macular degeneration using the Visual Geometry Group of the University of Oxford (VGG16) CNN algorithm. To determine the probability of age-related macular degeneration, the method encodes important picture information into a vector. A multi-layer neural network, such as an feed forward neural network, subsequently processes this vector.[77,78] Two research studies focused on glaucoma by applying supervised ML techniques to enhance identification and predict progression. An area under the curve (AUC) of 88% was obtained in the Chaganti *et al*. research for the diagnosis of glaucoma. The results showed that adding an EMR phenotype could improve the classification accuracy of a model using imaging biomarkers.[79] In contrast, Baxter *et al*. found modest performance, with an AUC of 67%, in their research utilizing EHRs to estimate the risk of advancement to surgery among individuals with open-angle glaucoma.[80] Several topics will require further investigation in the future. One area is the use of eye imaging not only for diagnosis but also for predicting the disease prognosis. This can assist doctors in planning medical treatments more effectively. In addition, while most current research relies on two-dimensional ocular images, exploring three-dimensional images obtained from optical coherence tomography, angiography or other devices could represent a new direction.

AI in oncology

In oncology, the incorporation of advanced AI technology into the clinical application will aid in improving the patient-lifespan. It will also help in early screening, accurate diagnosis, effective treatment, and improved diagnosis by identifying complex patterns and transforming image interpretation into a quantifiable and reproducible procedure. CAD and computer-aided diagnosis offer remarkable precision in early identification, characterizing and monitoring tumors, providing a new dimension to clinical decision-making for practitioners.[81] Oncology is increasingly turning to evidence-based medicine and modern diagnostic technologies such as gene expression assays and next-generation sequencing to improve cancer detection and treatment. Integrating these varied data sources may be too hard for typical analysis tools.[82] However, AI, particularly through Network and ML-based AI can overcome the barriers by learning patterns across the entire expression profiling. ML method uses whole expression profiling ribonucleic acid (RNA) sequence at multiple tumor profiles gives precise cancer detection even its rare types and predict the tumor origin. Neutral networks have also been utilized to classify the cellular subtypes of various carcinomas. AI has the ability to analyze large-scale comprehensive data, leads to discovery of drug susceptibility and RNA splice site prediction.[83,84] Recent studies in DL have shown remarkable success in cancer diagnosis and classification across various imaging modalities. Coudray *et al*.[85] developed the DeepPATH model using the Inception-v3 architecture, achieving an AUC of 0.97 in classifying lung cancer images into its subtypes. Esteva *et al*.[66] demonstrated that their DNN model outperformed 21 board-certified dermatologists in classifying skin lesions, with an AUC of 0.91–0.94, and effectively handled variabilities in digital photographs.[85] In radiology, Anthimopoulos *et al*. used computed tomography scans to build a DNN that identified an abnormality pattern in the lung disease with an average accuracy of 0.85, while Yuming Jiang *et al*. developed a model for predicting occult peritoneal metastasis in gastric cancers, achieving an AUC of 0.92–0.94.[86,87] Wang *et al*. analyzed MRI images to build a DNN capable of distinguishing prostate cancer identifying from non-cancerous conditions, with an AUC of 0.84.[88] These results demonstrate the potential of DL models to increase cancer detection and classification; nevertheless, more validation in prospective studies is needed to ensure their effectiveness and address potential issues such as false negatives.

ROLE OF AI IN INDIAN RESEARCH AND HEALTHCARE

AI has the transformative potential to propel Indian research and healthcare to new heights. AI technologies are being utilized to enhance the various aspects of medical research, includes improved data analysis, predictive modeling, and overall efficiency in addressing complex issues. AI plays a pivotal role from rational design to clinical trials. ML and DL technologies can expedite data collecting, biosimulation, and early disease diagnosis by deftly analyzing large datasets. This improves the accuracy of drug development procedures while also cutting expenses and time.[89] AI models play a pivotal role in forecasting pharmacokinetic (PK) and pharmacodynamic properties, allowing researchers to effectively identify compounds with suboptimal absorption, distribution, metabolism, and excretion profiles at an early stage in the drug discovery pipeline. This capability significantly reduces the likelihood of failure in later, more expensive stages of drug development.[90,91] AI has shown great promise in toxicity assessment, especially in the prediction of hepatotoxicity and cardiotoxicity. For example, utilizing publicly accessible pharmacological data, AI-based models have been created to predict cardiotoxicity with a high degree of accuracy. Likewise, these models have demonstrated good classification accuracy when used to forecast drug-induced liver damage. In later phases of drug development, the probability of compound failure is significantly decreased by this early identification of toxicity issues.[92-95] By improving medication formulations, enabling targeted drug delivery, personalized medicine, and optimizing PKs, AI is revolutionizing drug delivery, improving patient outcomes, and accelerating drug development.[96] Robotics and AI integration have demonstrated great promise in tackling the problems caused by India's enormous and diverse population. Rapid adoption to data patterns is made possible by AI systems' ability to evaluate large datasets using complex algorithms. This skill is useful in a variety of healthcare applications, including surgical support, hospital logistics optimization, and routine health check-ups, resulting in increased efficiency in both urban and rural healthcare settings.[97-99] For example, Custom CNN architecture model of AI algorithm helps in the rapid identification of COVID-19 during the pandemic.[100-103] Despite these advancements in AI, there remains a clear gap in AI-focused training within India's medical education system. Research evaluating medical students' understanding and perspectives on AI in healthcare has emphasized the urgent need for robust AI education to equip future healthcare professionals for the rapidly changing landscape. Bridging this educational gap is essential to ensure the seamless integration and effective application of AI technologies in clinical practice.[104,105]

CHALLENGES AND FUTURE PROSPECTIVE

Future prospects in the integration of AI into healthcare are promising but come with several challenges that need careful consideration. The current landscape demonstrates AI's disruptive potential in identifying diseases, monitoring, efficacy assessment, survival prediction, medication trials, and health care. ML aspires to develop algorithms that can self-improve through experience and continually learn from new data and insights, allowing them to answer various questions. Precision medicine benefits greatly from these advanced algorithms, though they bring considerable computational challenges. The ethical challenges arising from data science have been widely debated. These issues can be divided into three key areas of research data privacy ethics, the moral implications of algorithms, and the ethical values of data practices. By exploring these challenges within a conceptual framework, researchers can gain deeper insights and work toward resolving them.[106] One challenge in advancing robust algorithms for gastric cancer is the interpretability of AI. Some research has shown that ML and DL applications can achieve greater sensitivity and produce fewer false positives compared to radiologists.[107] There is a lot of enthusiasm about ML's potential in laboratory medicine, but there are also major obstacles to overcome. One major technical hurdle is the quality of data. Laboratory information systems often suffer from mislabeled or missing data, which constrains the peak performance of any algorithm. Furthermore, the financial and technological hurdles include the expense of the requisite computing infrastructure and the cost of recruiting professionals with the skills required to build, install, maintain, and update major tools.[108] Although there are some promising results, developing effective AI methods for analyzing comprehensive data is still challenging. Comprehensive data are very diverse, and simply combining raw data or model outcomes from each type often misses important connections between different types of data. Using network-based techniques, which depict things as nodes and relationships as edges, has enormous potential for more effectively integrating and studying comprehensive data.[109] Clinical trials often recruit "ideal" patients based on strict criteria, limiting their real-world applicability, while FDA adverse event reporting system data lack comprehensive details. Integrating these findings with data from EHRs and policies, as promoted by the FDA's new strategic framework, enhances their relevance and value.[110] In addition, an integrated AI system requires an expansion of translational research, emphasizing the need for investment in enhancing their current role performance in the healthcare workforce. Healthcare leaders must plan for ethical and responsible data access, ensuring that processes align with the sensitive nature of healthcare data. Access to sufficient computing power, especially in real-time decision-making, necessitates leveraging the exponential growth of cloud computing.[111]

CONCLUSION

Implementation of AI in real-world scenarios is pivotal for fostering trust in AI systems. Understanding the challenges that arise during the transition from development to real-world application is vital. Healthcare authorities must make it a priority to delve into the intricacies of constructing "trusted" AI, recognizing the intricate process of translating algorithms into viable, dependable solutions. Overall, the future prospects of AI in healthcare are promising, but success hinges on addressing regulatory, ethical, and technical challenges while also investing in education and preparedness of the healthcare workforce for a digitally augmented healthcare system. By integrating AI and 5G connectivity with advanced imaging, genomic analysis, pathology data and EHRs, healthcare systems can enable faster, more accurate , enhance personalized treatment plans and improve patient outcomes through real-time data monitoring and seamless communication across various medical field. Healthcare providers can offer a wide array of personalized treatment options. This technology enables real-time, individualized therapeutic strategies, significantly improving both the precision and effective patient care.

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Authors' contributions

ST: Conceptualization, manuscript drafting; ST, GJB: Literature review, final draft preparation, editing, submission, and correspondence.

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Use of Artificial Intelligence (AI)-Assisted Technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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