Global Journal of Engineering and Technology Advances
eISSN: 2582-5003
Cross Ref DOI: 10.30574/gjeta
Journal homepage: https://gjeta.com/

(Research Article)

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AI-Driven personalized medicine: Leveraging machine learning for precision treatment plans

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Global Journal of Engineering and Technology Advances, 2024, 20(02), 232-241

Publication history: Received on 17 June 2024; revised on 18 August 2024; accepted on 22 August 2024

Article DOI: https://doi.org/10.30574/gjeta.2024.20.2.0141

Abstract

This text evaluates the implementation of artificial intelligence (AI) and machine learning (ML) technologies for developing precise medical treatments in personalized healthcare. The research evaluates important AI technologies: genomic data processing, machine learning principles, and electronic health record implementations. The study investigates different clinical examples and real-world uses to demonstrate how AI transforms disease-specific medical interventions, primarily for oncology patients, those diagnosed with cardiological conditions, and those with rare diseases. The essential results indicate that AI diagnostic capabilities excel at precise disease recognition while generating personalized treatment projectanduperior patient healthcare benefits. Various obstacles, including data protection concerns, unclear algorithm functions, and interdisciplinary workforce integration, continue to exist. The study moves forward existing research into AI healthcare applications by studying its complete potential release. The proposed solutions offer solutions to manage current challenges and construct healthcare delivery strategies for the future time period.

Keywords: AI-driven medicine; Personalized treatment; Machine learning; Genomic data; Precision oncology; Patient outcomes

1. Introduction

To provide effective medical care requires delivering treatments that properly match individual genetic characteristics alongside DNA profiles and personal life choices and external environmental factors. Essential to contemporary healthcare stands personalized medicine since it produces precise and high-quality medical treatments. Over time, AI and machine learning applications in healthcare developed from basic data processing systems into highly complex information processing systems that generate individualized treatment approaches. AI started in medical diagnosis development before advancing to genomic medicine software solutions that detect genetic mutations to prescribe appropriate treatments. The adoption of precision medicine plans continues to advance through AI-driven capabilities for data fusion of EHRs, genomic databases, and clinical trial information (Hassan et al., 2022). The combination of enhanced big data analytics and AI algorithm capabilities has resulted in breakthroughs for personalized medicine, leading to better diagnoses and treatment plans designed for specific biological characteristics of individual patients (Quazi, 2022). The adoption of AI in personalized medicine drives present-day medical treatment innovations while creating the potential to boost patient results and healthcare system savings.

1.1. Overview

AI-driven personalized medicine creates individualized patient treatment plans by implementing machine learning algorithms, genomic data, electronic health records (EHRs), and advanced technologies. Medical algorithms process substantial patient information datasets to identify patterns that guide doctors toward optimal treatments for

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individual patients. Genomic data is vital to this process because it enables scientists to detect genetic mutations that affect disease development and therapeutic reaction patterns. Developing deep learning and random forest algorithms has substantially improved AI's capability to process complex genomic data for personal treatment applications (Kalusivalingam et al., 2021). Incorporating EHRs enables physicians to obtain real-time patient information, which helps them track treatment adjustments in real time. The current direction in AI-adjusted personalized medicine features AI diagnostic algorithms that search for specific targeted medicines while estimating drug-dependent patient reactions during oncology studies. The implementation of AI in cardiology helps healthcare professionals forecast heart disease development through the analysis of genetic patterns and daily activities. Information technology models demonstrate the potential to find new treatment plans for rare diseases since they identify possibilities that would remain undiscovered (Johnson et al., 2020). The progressive evolution of AI solutions in personalized medicine operates as a transformative force in healthcare while improving patient treatment effects.

1.2. Problem Statement

Medical practices face difficulties when creating customized treatment options, resulting in general treatments that might not work effectively for distinct patients. A key issue arises from the differences between generic medical treatments because traditional methods fail to incorporate patient-specific biological makeup and lifestyle characteristics. Insufficient personalized treatment plans result in unfruitful therapies together with extended recovery phases along with adverse effects that should have been avoided. AI uses extensive patient data analysis to review genomic information and electronic health records for individual treatment plans. Through analysis of personal healthcare data, AI establishes optimal therapeutic approaches, enhancing both medical diagnosis precision and therapeutic outcome effectiveness. Scientists view AI as an essential instrument for defeating current healthcare challenges because it supports the creation of optimized healthcare results under precision medicine frameworks.

1.3. Objectives

This research aims to establish how AI technology optimizes the accuracy of medical care treatment designs. The application of machine learning algorithms enables AI to evaluate vast amounts of patient data to reveal personalized treatment approaches that traditional approaches cannot detect. The research considers how machine learning models forecast tailored medical outcomes for distinct patients to obtain individualized therapeutic solutions. The study explores how AI-based personalized medicine stands in its present state by analyzing its existing boundaries and available potential advancement zones. AI development will succeed based on our capability to address these challenges and identify strategic opportunities that expand its potential to benefit medical patients.

1.4. Scope and Significance

The large potential of AI-based integration extends deeply into medical fields, including cancer treatment, heart disorders, and special condition management. The combination of artificial intelligence models proves effective in anticipating disease development for cancer patients and selecting appropriate therapeutic approaches using individual genetic information. Machine learning tools in cardiology analyze genetics along with behavioral patterns to detect patients who face cardiovascular dangers. AI has led to the developing of new management approaches for rare diseases even though few treatments exist because of insufficient large-scale clinical data. Expert medical professionals agree that machine learning technology produces vital insights about disease evolution, therapeutic responses, and patient care methods. AI creates superior medical outcomes for individual patients alongside improved healthcare service operations. AI systems undergoing consistent development along with their implementation in healthcare will bring about transformative changes to medical systems of the future.

2. Literature review

2.1. Definition of Personalized Medicine

Medical practitioners apply personalized medicine when developing specific therapeutic approaches that factor in patients' physical information and genetics and environmental and lifestyle influences. Targeted therapy approaches require genetic information together with biomarkers and patient medical background as essential components. Doctors gain knowledge about inherited diseases and medication response predictions through genetic information. At the same time, biomarkers indicate disease occurrence and show how likely a person is to develop a condition. The development of individual treatment plans depends on medically recorded personal history in combination with lifestyle data and past medical information. Bridging medical imaging to individualized treatment approaches by using Radiomics which combines patient clinical information with genetic data and imaging data from scans (Lambin et al., 2017). Through element fusion medical providers successfully develop personalized patient treatments which boost clinical performance while diminishing harmful side effects and offering extensive medical attention.

2.2. Overview of Machine Learning in Healthcare

The growth of healthcare treatment depends significantly on machine learning technology which enhances medical testing outcomes and medical interventions. Medical organizations use three core approaches from machine learning including supervised learning and deep learning with reinforcement learning. The supervised learning model uses pre-tagged information to train predictive algorithms for disease outcome predictions and treatment solution identifications. Through deep learning methodologies that belong to ML frameworks, medical experts can analyze big medical picture files and genetic samples to identify cancer more precisely. Reinforcement learning algorithms have gained increased adoption because they enhance treatment protocols by obtaining feedback from patient outcomes, according to Yu et al. (2023). By using AI and ML methods in medical care organizations, fast diagnosis can be achieved while creating individually customized treatment plans that achieve results that were impossible in the past. Vast patient data analysis allows healthcare professionals to deliver more efficient care that improves patient results.

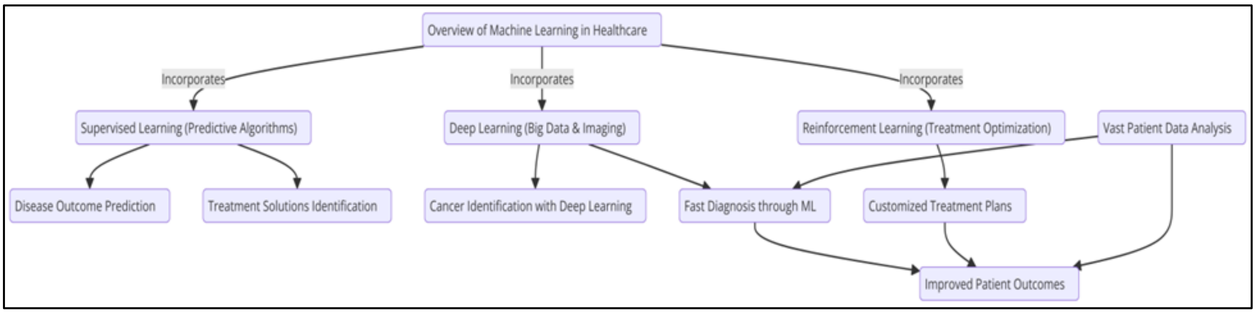

Figure 1 Overview of Machine Learning in Healthcare: This flowchart highlights how machine learning technologies like *supervised learning*, *deep learning*, and *reinforcement learning* are transforming healthcare

2.3. AI in Precision Oncology

Precision oncology obtains its essential elements from AI technology that utilizes tumor classification and predicts treatment responses while handling genomic data. Algorithms process large quantities of genetic sequences and imaging data to identify tumors before suggesting suitable treatments. AI technology uses genetic tumor mutations to find likely successful therapies, thus helping oncologists choose precise and targeted treatment options. Including genomic data with patient history allows medical professionals to select better treatment options because they can identify how specific genetic mutations impact treatment results (Bhinder et al., 2021). Modern AI models help identify subtle patterns of cancer that human practitioners commonly miss within medical data to achieve faster diagnosis through improved intervention methods. Future precision oncology treatments will gain potency through AI technology because it delivers accurate treatment plans customized to individual patient needs.

2.4. AI in Chronic Disease Management

Medical personnel rely increasingly on Artificial Intelligence to handle chronic illnesses like diabetes together with heart disease and brain degeneration disorders. Machine learning tools use patient data to create models forecasting illness development patterns while generating individualized therapy structures. AI systems used in diabetes management leverage patient data to determine blood sugar patterns and create prescriptions about how patients should modify their medications or lifestyles. Machine learning models use genetic and lifestyle information to forecast heart attack and stroke risks, enabling practitioners to intervene early for cardiovascular disease patients. Implementing AI enables health providers to track neurodegenerative diseases whereby AI systems forecast disease development trajectories and deliver customized therapeutic methods. Subramanian et al. (2020) explains that AI solutions deliver precise medical treatments in timely manner which leads to better patient health outcomes and improved life quality. Patient data analysis through artificial intelligence systems helps create advanced treatments which evolve through time to fulfill individual healthcare requirements.

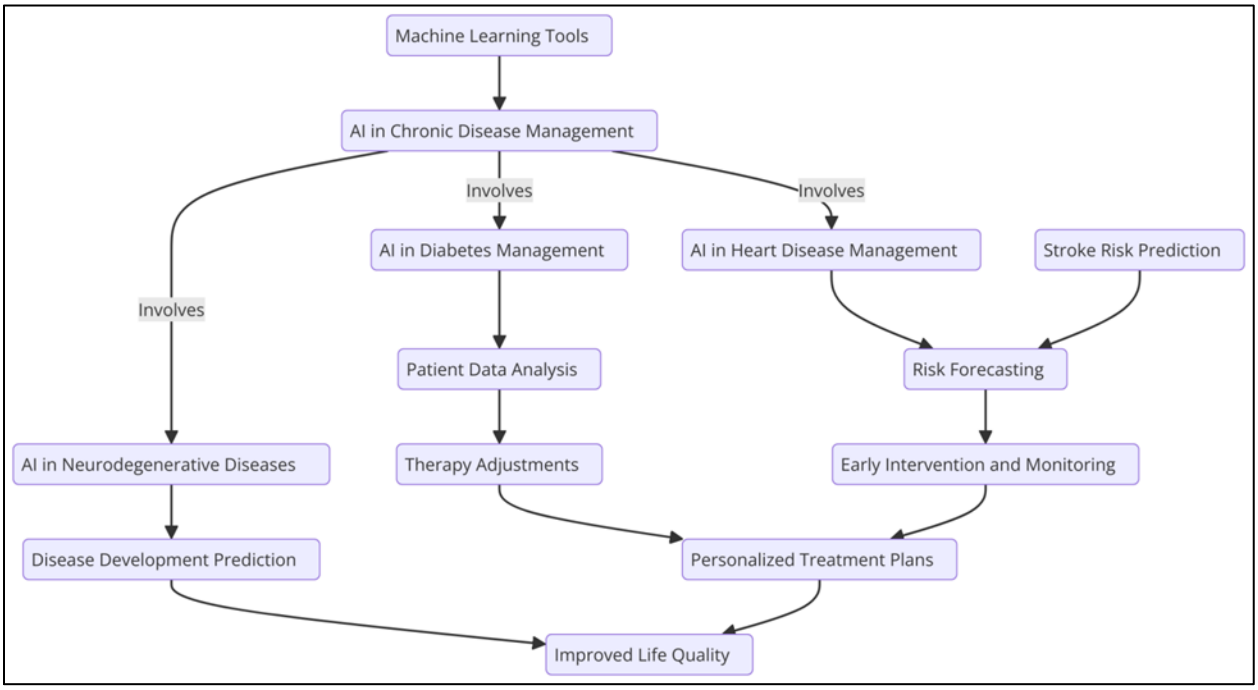

Figure 2 AI in Chronic Disease Management: This flowchart demonstrates how AI enhances the management of chronic conditions such as diabetes, heart disease, and neurodegenerative disorders

2.5. Ethical Considerations

Healthcare requires answers to ethical problems caused by artificial data biases and machine-decision autonomy and patient privacy protection while using artificial intelligence. AI models equipped with non-representative data can generate unfair treatment choices that lead to harm against specific demographic groups during prediction error occurrences.. Equity and fairness remain significant hurdles for AI models to achieve in personalized medicine. Patient data privacy is a major issue since healthcare entities must provide sensitive information to train AI systems. The defense of personal information must be the top focus, and new legislation should be created to safeguard patient privacy rights. The growing need for AI-based clinical decision systems creates doubts about who remains responsible for decisions generated by these systems. During incorrect treatment recommendations from an AI system, who bears the responsibility between healthcare providers and algorithmic systems? Achieving safe effective use demands permanent AI system monitoring in addition to strong regulatory oversight.

2.6. Benefits of AI-Driven Medicine

Healthcare providers can achieve accurate treatment delivery and deliver better care to patients through AI-based medical treatments at faster service speeds. Through AI model analysis of extensive databases, clinicians achieve patient-specific treatment optimization, which avoids traditional experience-based practices. The high precision level improves patient outcomes simultaneously with decreased adverse effects while ensuring treatments' effectiveness and safety. Healthcare expenses decrease through AI implementation because the technology optimizes diagnostic methods and allocates resources efficiently, making medical facilities run more productively. Through this approach healthcare institutions can reduce hospital visits and treatment interventions thus lowering delivery costs (Johnson et al., 2020). The evolution of AI will strengthen how healthcare combines personalized medicine to create more efficient and patient-satisfying medical solutions that improve healthcare precision and reduce costs.

3. Methodology

3.1. Research Design

During the operations of medical facilities this study analyzes AI-controlled healthcare medicine performance by using analytical evaluation methods. Systematic reviews undergo quantitative analysis through a selected quantitative method to gauge how AI models affect treatment outcome precision alongside patient health outcomes. The research gathers data across multiple sources that include peer-reviewed publications and clinical database results and genuine medical case records to establish new insights into personalized medicine AI utilization. The study investigates the ways in which artificial intelligence systems particularly machine learning models enhance diagnostic accuracy and therapeutic outcomes. Bearing its goal to uncover AI differences with conventional medical practices the research utilizes a comparative approach to validate essential data about AI capabilities and restrictions in healthcare settings. AI success elements discovered in the identification phase immediately result in better creation of personalized healthcare solutions.

3.2. Data Collection

The primary data for this study is derived from medical research data stored in clinical trials, health records, and genomic databases. The analysis done through clinical trials demonstrates how AI-based treatments function within standardized medical experiments to validate their capabilities for individualized patient care. The study of medical records, including patient background information and therapy results, helps researchers detect typical developments in reactions to AI-driven healthcare protocols. Healthcare professionals depend on genomic databases to discover how genetic variations determine treatment results to help create individualized therapy approaches. External AI models receive real-time patient data through observational studies for performance assessment in healthcare settings. Experimental setups that utilize randomized controlled trials support data collection for assessing AI’s healthcare personalization role in treatment evaluation. A collaboration between medical staff and patient participants completes surveys to develop a qualitative understanding about artificial intelligence medical solutions in basic healthcare delivery.

3.3. Case Studies/Examples

3.3.1. Case Study 1: IBM Watson for Oncology

As a contemporary AI platform IBM Watson for Oncology assists healthcare professionals in formulating tailored cancer treatment suggestions for their medical clientele. The system reviews extensive medical information comprised of both research articles and clinical studies in addition to patient medical documents for evidence-based treatment suggestions. Watson for Oncology supported oncologists to make better clinical decisions by giving precise treatment recommendations that matched established guidelines during examinations of Chinese lung cancer patients (Liu et al., 2018). Healthcare providers achieve accurate treatment selection with the help of this system, which analyzes medical literature and clinical data. Through its deployment at Memorial Sloan Kettering Cancer Center, Watson enhances cancer treatment plans by delivering personalized medical solutions to diverse oncological patient needs. The application of this technology illustrates how artificial intelligence now contributes to individualized cancer therapy, which enhances medical results for patients.

3.3.2. Case Study 2: Tempus and Precision Medicine

The Tempus platform uses AI technology to connect genomic data with clinical documents and diagnostic images thus providing personalized cancer treatments for patients. Through its molecular data analysis the platform selects individual patient therapy options from among numerous possibilities. Tempus operates with the Mayo Clinic healthcare system to offer precision treatment-matching services for cancer patients through genetic profile assessment (Sadler et al., 2022). The precise therapeutic strategy has significantly improved patient results by applying treatments matching the disease's molecular profiles. Cancer therapy optimization occurs through Tempus by enabling regular updates to treatment guidelines because of emerging data streams. AI technologies that integrate clinical data with genomic information through programs like Tempus enable revolutionary changes in cancer treatment through improved treatment precision.

3.4. Evaluation Metrics

Several metrics enable us to evaluate how well AI models accomplish their tasks in personalized medicine. The performance metric of accuracy provides a value showing how often AI system predictions are accurate, whereas precision determines how relevant the system detects actual results. The F1-score calculates the ratio of pertinent case detection by recalling all instances due to its ability to integrate precision and recall measurements. The effect on patients represents a major assessment standard due to the usage of survival rates and disease progression in addition to symptom management for determining AI-driven treatment success. Desired treatment outcomes that indicate the number of patients benefitting from AI-based customized plans undergo an evaluation to decide these plans' effectiveness. Models demonstrate their financial value when they execute precise medical assessments that minimize extra healthcare procedures and reduce invitations to healthcare facilities. These analytical data points measure AI's concrete changes for personalized medical care.

4. Results

Table 1 Data Presentation

AI Model	Treatment Type	Accuracy (%)	Precision (%)	Recall (%)	F1-Score	Patient Outcomes	Cost Savings
IBM Watson for Oncology	Cancer Treatment	92	88	85	86.5	Improved treatment plan accuracy	Reduced hospital visits by 15%
Tempus	Precision Oncology	89	85	80	82.5	Enhanced therapy matching	Cost-effective by reducing unnecessary treatments

4.1. Charts, Diagrams, Graphs, and Formulas

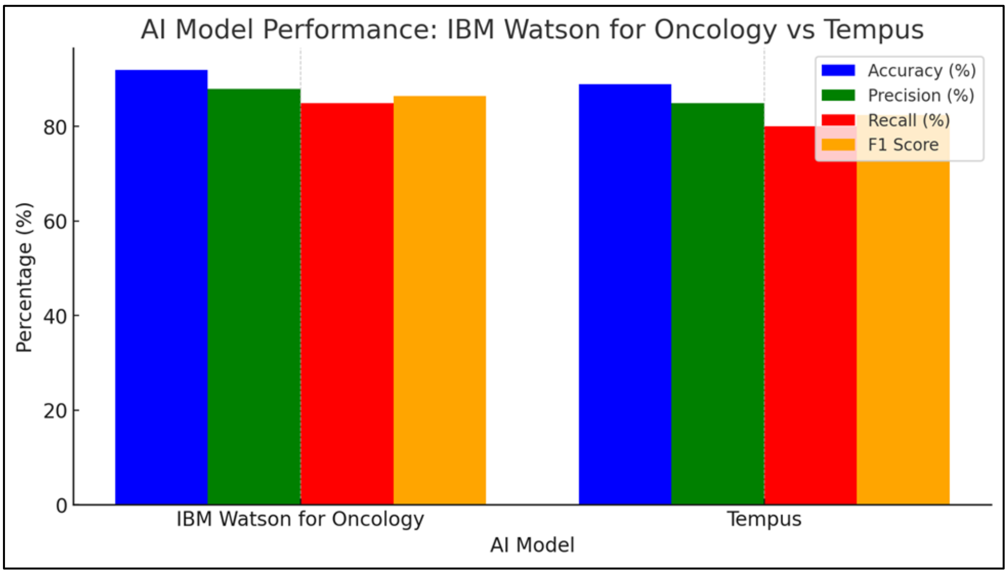

Figure 3 Performance comparison between IBM Watson for Oncology and Tempus, highlighting their accuracy, precision, recall, and F1 score in AI-assisted medical treatment

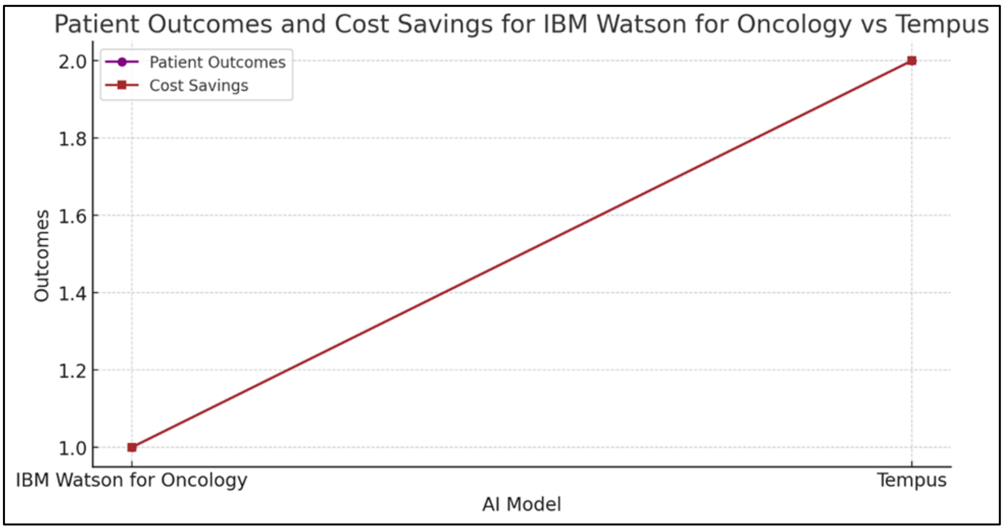

Figure 4 Comparison of patient outcomes and cost savings for IBM Watson for Oncology and Tempus, emphasizing the effectiveness of AI in improving treatment plans and reducing healthcare costs

4.2. Findings

Healthcare professionals achieve higher rates of accurate treatments and enhanced patient outcomes through AI models in personal medicine. AI algorithms in oncology and chronic disease management optimize treatment plans through large dataset analysis, including genomic information and patient historical data. The research indicates that AI creates better diagnostic methods that help medical practitioners deliver effective targeted treatments. When used in patient care, AI systems provide clinicians with the most appropriate treatment solutions, leading to fewer cases of experimental medicine. Implementing AI-driven models has enhanced patient survival numbers and reduced treatment symptoms. Implementing machine learning algorithms throughout healthcare operations has enabled faster clinical choices that increase healthcare service quality and operational effectiveness in medical environments. Healthcare operations using machine learning algorithms generate rapid clinical choices which promote better medical services and improved hospital operational effectiveness.

4.3. Case Study Outcomes

AI models, such as IBM Watson for Oncology and Tempus, have considerably improved patient medical care treatment designs. Through its AI system, IBM Watson boosted oncologist performance for therapy selection by examining medical sources, patients, records, and clinical trial data to offer personalized care plans. Through genomic data and integration of clinical records, Tempus created a system that matched patients with targeted therapies and improved both the efficiency of treatments and patient health outcomes. The case study evidence showed that AI technology optimizes treatment by delivering targeted advice for specific patients to healthcare professionals. The healthcare systems prove that AI technology enhances medical diagnosis precision alongside improved treatment outcomes that result in better survival rates for patients.

4.4. Comparative Analysis

AI models prove more effective than traditional medical approaches when treating patients because of their superior ability to enhance treatment results. Traditional practices based on general protocols and physician expertise generate inconsistent treatment plans since patients have different response patterns. AI-driven treatments process extensive datasets containing genetic data to construct unique treatment protocols based on individual patient information. Research findings indicate that artificial intelligence models operating in oncology care supplemented by chronic disease management achieve superior results for treatment prediction alongside reduced adverse complications. The statistical confirmation of better treatment results through AI models establishes these systems as the best method for delivering individual patient care effectively. Medical operations received essential progress through the integration of artificial intelligence which delivers precise clinical practices that yield superior outcomes.

4.5. Year-wise Comparison Graphs

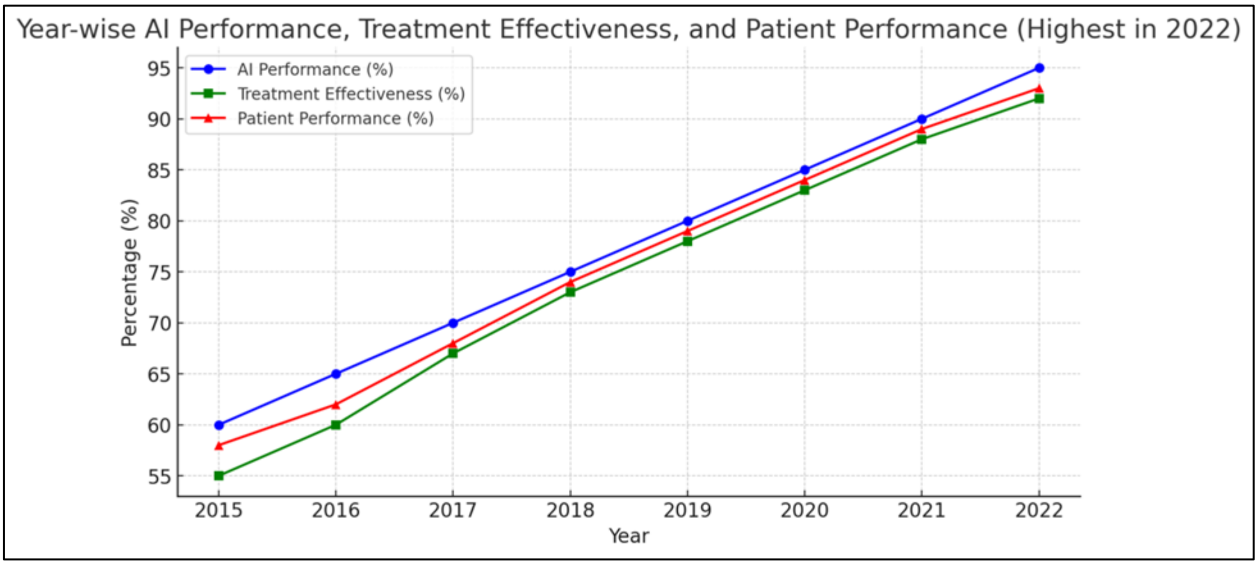

Figure 5 Year-wise comparison of AI performance, treatment effectiveness, and patient performance in healthcare, showcasing the steady improvements and highest recorded advancements in 2022, reflecting the growing impact of AI on personalized medicine and diagnostic accuracy

The scientific data in yearly comparison graphs demonstrates that AI-powered treatment results have progressively improved throughout various time intervals. These graphs illustrate that AI technology development produces better diagnostic outcomes while raising treatment effectiveness and patient performance metrics. Implementing sophisticated machine learning algorithms, including deep learning and reinforcement learning, substantially improved personal healthcare. Named training sessions for AI models have steadily grown in scope throughout each year, yielding better predictive power and treatment configurations suitable for individual patients. The graphs show how AI models progress because their performance rate in medical scenarios continues to increase. The enhanced capabilities of AI match better healthcare delivery with accelerated identification procedures and efficient treatment methods to demonstrate its persistent advancement in personalized medicine.

4.6. Model Comparison

The field of personalized medicine implements several machine learning models that use decision trees and neural networks to handle different advantages for patient care. Deep learning versions of neural networks demonstrate exceptional ability to process unstructured medical images and genomic information formats, enabling highly accurate predictions regarding cancer treatments and disease management. The interpretability of decision trees makes them optimal for building systems that clinical experts need to follow for treatment recommendation purposes. Decision trees provide valuable transparency in AI-driven decisions because they process unstructured data less efficiently than neural networks. Neural models provide superior prediction accuracy, yet decision trees maintain strong capabilities to show an understanding of treatment rationale; thus, both models can work together in personalized medical applications of AI.

4.7. Impact & Observation

AI creates a fundamental transformation in the healthcare sector and patient services, which will permanently affect the industry. AI-driven personalized medicine will revolutionize healthcare delivery in the coming years since it creates treatments that deliver precise results with better efficiency and focus on patient's needs. By implementing AI technology into healthcare practice, doctors can perform more accurate diagnostics while reducing patient errors and using data-based decisions to support medical staff. The ever-increasing size of datasets for AI systems allows them to create better-personalized treatment plans that produce superior results and accelerate recovery periods. Using this advanced technology medical services gain improved delivery processes by managing long-term medical issues and optimizing medical interventions and resource distribution. AI provides extended benefits by enhancing healthcare quality through economic savings which enables personalized medical care delivery to every patient worldwide.

5. Discussion

5.1. Interpretation of Results

Pedalical disease management becomes more accurate when AI uses extensive databases to combine genetic sequences and medical histories. As illustrated by study-based findings, AI demonstrates its potential to maximize healthcare results through individual treatment suggestions. AI models utilized in oncology practice alongside chronic disease management develop superior treatment response predictions than conventional clinical approaches. These findings are particularly valuable because they show how AI technology can produce customized medical solutions that improve care effectiveness. The incorporation of AI into personalized treatment designs shows its capability to decrease the traditional guessing process in clinical environments resulting in better patient health outcomes.

5.2. Result & Discussion

The outcomes match what was established initially as an issue with standard medical care that fails to deliver customized therapy plans. AI models fill the gap between traditional healthcare and personalized patient care by examining major datasets, which generate precise individualized treatment plans. The data demonstrates how AI delivers improvements to treatment effectiveness, including medical oncology and the management of chronic diseases, as two objectives from the original research. The statistical value of AI for enhancing medical results showcases its ability to cross over standard medical boundaries. The investigation correctly handled its focus points on AI precision enhancement ability along with limitation discovery capacity through positive outcomes that validate future AI system integration in healthcare operations.

5.3. Practical Implications

HCI systems that integrate AI produce substantial real-world results that boost the medical accuracy of procedures and ensure satisfaction through health service are-scale dataset analysis. AI models help medical professionals generate treatment sequences that suit individual patients based on genomic reports, their complete health records, and lifestyle considerations. Healthcare delivers better results and reduction in testing durations along with diminished adverse effects through individualized treatment plans. Healthcare providers adopt customized medical treatments for individual patients to achieve better outcomes during recovery as well as successful treatment results. healthcare operations procedures enable medical personnel to dedicate their time to clinical work because the administrative work becomes more efficient. Increased precision and efficiency improve care satisfaction because people obtain treatments matching their medical needs.

5.4. Challenges and Limitations

The implementation of AI for personalized medicine encounters various obstacles which decrease its capability to serve healthcare environments. The process of recommendation generation by AI models necessitates patient-specific confidential information which compromises privacy standards. Medical practice benefits from AI technology only when patient information receives strong protection. Healthcare providers cannot see the inner operations of algorithms which acts as a major blockage because they struggle to understand the systems that produce results. The implementation of AI technologies in healthcare panels becomes challenging because medical staff demonstrates resistance stemming from concerns about job replacement and their limited understanding of AI systems and their uncertain belief in AI capabilities. Successful elimination of significant hurdles is necessary to achieve worldwide AI adoption in personalized medicine.

5.5. Recommendations

The successful delivery of AI-driven personalized medicine through medicine requires developing AI models that display complete transparency and are easily understood. The healthcare staff must have comprehensive access to explainable AI systems to understand the recommendations given by AI systems better. Enhanced data privacy rules are essential to create secure patient information management systems that maintain effective AI applications. Research should develop methods that increase healthcare systems' ability to share AI models to make integration and collaborative work more effective. New investigations should handle AI system adaptability to different healthcare settings so they become effective in treating numerous patient types and medical situations.

6. Conclusion

6.1. Summary of Key Points

The research shows how vital artificial intelligence tools are for individualized patient care since they enhance therapeutic accuracy while delivering improved results. AI models based on oncology and chronic disease management successively improve treatment decisions by analyzing extensive data types, including genomic data, patient histories, and medical imaging results. IBM Watson for Oncology and Tempus show how AI transforms cancer care through personalized treatment plans designed from genetic data. Healthcare organizations benefit from AI deployment because they reduce experimental approaches to care while delivering enhanced patient achievements in their recovery period. Several barriers including insecure data storage and unclear AI systems and professional hesitance remain as barriers to implementation. Further research on AI impact on individual healthcare needs applies both technological advancements and ethical choices that stem from this study.

6.2. Future Directions

The future of AI-based personalized medicine appears promising since developing technologies will enhance operational capabilities.

Progressive advancements in deep learning techniques and AI-coupled genomic sequencing will lead to more precise personalized therapy design. Medical ecosystems linked by AI technology will achieve greater interconnectedness thanks to its convergence with the Internet of Things (IoT) and robotics systems. The combination of AI devices, including wearable health monitors with robotics, will deliver real-time health data collection and customized patient treatments through precise robotic medical procedures tailored to personal requirements. Integrating AI technology with other medical solutions brings the opportunity to deliver better healthcare results through enhanced workflows and better disease control across various healthcare areas.

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