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(Review Article)

From stethoscopes to supercomputers: The AI revolution in medicine: A review

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Abstract

Artificial Intelligence (AI) has rapidly emerged as a transformative force in modern medicine, revolutionising diagnostics, treatment personalisation, and clinical decision-making. This review synthesises current literature on AI's evolution, applications, challenges, and future directions in healthcare. From early rule-based systems to advanced deep learning algorithms, AI has consistently demonstrated capabilities that rival and enhance human expertise—particularly in imaging, predictive analytics, and drug discovery. The role of AI in global health is also expanding, offering scalable solutions to reduce disparities in low-resource settings. However, the integration of AI raises ethical and legal concerns, including data privacy, algorithmic bias, and unclear accountability frameworks. Drawing on the Technology Acceptance Model (TAM), Diffusion of Innovations Theory, and Principlism, this review highlights theoretical perspectives essential to understanding AI adoption and governance. The paper concludes with a call for longitudinal studies, ethical frameworks, and policy innovations to support AI's responsible and equitable deployment in the medical field.

Keywords: Artificial Intelligence; Medical Diagnostics; Personalized Medicine; Clinical Decision Support; Medical Imaging; Predictive Analytics; Healthcare Ethics; Algorithmic Bias; Global Health; Explainable AI

1. Introduction

Medical professionals are transitioning into a new era of healthcare delivery, as Artificial Intelligence combines computational capabilities with clinical practice. Artificial Intelligence has progressed beyond the speculative stage to offer direct and transformative benefits for disease diagnosis, treatment design, and patient management [1]. Using AI-powered systems demonstrates both technological advancement and a significant transformation of medical practice methods, though it replaces traditional diagnosis tools with digital systems.

The combination of machine learning, natural language processing, and computer vision technology enables artificial intelligence to analyse extensive medical datasets with superior accuracy and great speed. The data analysed through these capabilities proves especially helpful in radiology, dermatology, and genomic fields, where precision and pattern recognition are crucial [2, 3]. AI algorithms achieve comparable labeling outcomes to expert clinicians when performing check-ups through image-based analysis and sometimes provide even better results (Dodda et al., 2024).

AI has established itself as an essential component that helps generate personalised medical predictions. AI examines genomic, proteomic, and patient historical data to predict disease risks and create patient-specific medical treatments, representing progress in precision healthcare [4, 5]. These abilities represent a significant shift from traditional treatment protocols, evolving toward more complex, data-driven assessment procedures.

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Due to its rapid adoption, the integration of AI into clinical operations has presented various substantial challenges related to ethics and laws and implementation difficulties. The professional implementation of AI systems requires careful consideration of four key issues: algorithmic bias, data privacy requirements, regulatory control functions, and clinician trust mechanisms [6, 7]. The potential of AI will diminish when there is inadequate governance alongside insufficient transparency, as unintended harms are likely to arise.

This paper examines the historical development and presents AI's medical applications and projected uses in modern healthcare. It demonstrates how AI diagnostic power supports medical decisions, individualized treatments, and global healthcare operations, although it encounters implementation challenges.

1.1. Background Information

Medical professionals now utilise Artificial Intelligence systems to transform the traditional healthcare landscape by offering data-driven, accurate, and efficient personalised diagnostic and treatment options. Artificial Intelligence simulates human intelligence processes through machine systems, particularly computer systems, to achieve learning, perform reasoning, and facilitate self-correction [8]. AI apps today maintain their core capabilities based on this basic definition, which provides an effective understanding of AI functions.

AI technologies faultlessly analyse vast datasets, including electronic health records (EHRs), imaging data, and genomic information, creating impactful patterns for clinical decision support [1, 5]. Machine learning algorithms, a subset of artificial intelligence, learn patterns from data and make predictions through experience with new datasets [9]. AI models demonstrate superior performance beyond statistical techniques in detecting disease risks and determining disease pathways, making them valuable for diagnostic and predictive analytics applications [10].

AI enables personal medicine techniques that adapt therapy protocols to match biologically unique patient characteristics, known as precision medicine. Combining genomics and proteomics examination with patient history analysis enables AI systems to predict treatment outcomes. This directs physicians to match patients with treatments that offer superior effectiveness without unnecessary adverse effects [4]. Medical treatment approaches differ substantially through this approach because they typically deliver generalised solutions to universal patient populations.

Various important hurdles exist when deploying AI technology in medical settings. Numerous legal and privacy challenges surround using extensive personal healthcare data for analysis due to data protection rules and consent obligations [7]. Through AI systems, medical data biases persist, leading to unequal healthcare diagnosis and treatment allocation that affects distinct demographic populations [11]. Proper monitoring absence creates issues that endanger AI-based medical care's reliability and safety characteristics.

Medical organizations need to actively develop specific laws that define the responsible party when computer technology assists medical decisions. According to Cestonaro et al. [11], new policies are needed because existing liability models are insufficient to manage complex AI systems.

Healthcare management systems dedicated to AI integration require development to address technical, ethical, and regulatory challenges in deploying AI solutions. Interdisciplinary teamwork must persist because this approach allows healthcare professionals to achieve the benefits of AI and defend human worth in medical practice.

1.2. Objectives of the Review Paper

This review paper's primary objective is to investigate Artificial Intelligence's role in shaping modern medicine, examining its impact on clinical practice, diagnostic technologies, and individualised therapeutic approaches. This paper evaluates recent developments in AI technology for medical fields by examining their impact on healthcare services and patient outcomes.

The research examines the development of AI in medical applications, from rule-based systems to the modern era, where machine learning, combined with deep learning, dominates. Understanding AI development, from its earliest programs to the present and foreseeable future functions, depends on understanding its historical progression [12, 9].

A research goal is to investigate the medical value provided by AI systems, specifically in the areas of diagnosis and imaging methods. According to research from Dodda et al. [10] and Li et al. [3], AI systems now achieve better accuracy and efficiency through automated pattern recognition in radiological, dermatological, pathological, and ophthalmological imaging systems. The review presents research on recent advancements alongside a performance evaluation comparing artificial intelligence systems to human professionals.

Through this review, researchers examine the way that AI supports features of personalised medical care and disease prognosis. AI's analysis of complex datasets enables healthcare providers to create personalized treatment options and predict disease progression, thereby enhancing intervention effectiveness and speed [1, 5].

The research investigates the ethical, legal, and social consequences AI brings to healthcare systems. The paper addresses crucial data privacy problems, alongside algorithmic bias, transparency, and accountability questions, because these challenges need resolution for risk-free, equitable AI deployments [7, 11, 6].

This review discusses existing research gaps and recommends investigations into developing approachable regulatory systems, interdisciplinary teaching and implementation methods, and scalable AI solutions for clinical use.

1.3. Research Questions

This review paper uses the following research questions to investigate how Artificial Intelligence influences medical practice and its corresponding consequences:

- How has AI evolved in the field of medicine, and what are the key milestones in its development?
- In what ways is AI currently applied in medical diagnostics, imaging, and clinical decision-making?
- How does AI contribute to personalised and predictive medicine, and what are the implications for patient outcomes?
- What are the ethical, legal, and regulatory challenges associated with integrating AI into healthcare systems?
- How can AI be effectively implemented in low-resource and global health settings to address disparities in care delivery?
- What are the current limitations of AI in medicine, and what future directions should research and policy focus on to ensure responsible and effective use?

2. Methodology

2.1. Research Design

This paper adopts a narrative review methodology to explore and synthesise current academic and clinical perspectives on the role of Artificial Intelligence (AI) in modern medicine. A narrative review is particularly well-suited for emerging interdisciplinary fields, such as AI in healthcare, as it enables a comprehensive, flexible, and thematic examination of diverse literature sources [13]. Rather than adhering to a rigid protocol, this review aims to develop a conceptual understanding by identifying patterns, trends, theoretical frameworks, applications, and challenges related to AI in the field of medicine.

2.1.1. Search Strategy

A targeted literature search was conducted across major academic databases, including PubMed, Scopus, Web of Science, and Google Scholar, to ensure breadth and depth of coverage. Peer-reviewed articles published between 2018 and 2024 were prioritised, with exceptions made for foundational texts. The search focused on identifying influential and high-quality studies relevant to clinical applications, technological advancements, and ethical or regulatory considerations in the field of AI.

2.1.2. Search Terms & Boolean Operators

The following search terms and Boolean combinations were used to retrieve relevant sources:

- “Artificial Intelligence” OR “AI” AND
- “Medicine” OR “Healthcare” OR “Medical Practice” AND
- “Diagnostics” OR “Medical Imaging” OR “Clinical Decision Support” OR “Personalized Medicine” OR “Predictive Analytics” AND
- “Ethics” OR “Bias” OR “Legal Issues” OR “Global Health” OR “Data Privacy”

Techniques such as truncation (e.g., "diagnos*") and phrase searching (e.g., “clinical decision support”) were employed to broaden and refine the search results.

2.1.3. Inclusion and Exclusion Criteria

Inclusion Criteria

- Peer-reviewed articles published between 2018 and 2024.
- Research focuses on AI applications in human medicine, including diagnostics, imaging, personalised treatment, and predictive analytics.
- Studies addressing AI's ethical, legal, regulatory, or global health implications.
- Articles published in English.

Exclusion Criteria:

- Studies focused on veterinary applications or non-medical domains.
- Opinion pieces, editorials, or non-peer-reviewed content.
- Articles with insufficient methodological detail or lacking empirical support.

2.1.4. Limitations

This review acknowledges several limitations inherent in the narrative review approach:

- The restriction to English-language literature may exclude valuable research in other languages.
- The rapid pace of AI development means some emerging innovations may not yet be reflected in peer-reviewed publications.
- Excluding grey literature (e.g., white papers and technical documentation) may exclude industry insights and real-world implementations.
- Publication bias may skew findings, as studies with positive outcomes are more likely to be published.

Despite these limitations, this narrative review provides a structured and thematic exploration of current developments, challenges, and future directions in the application of AI in medicine, informed by the most relevant and recent academic contributions.

3. Literature review

3.1. Historical Evolution of AI in Medicine

Since its historical beginnings, artificial intelligence (AI) in medicine has followed the overall pattern of digital transformation in healthcare systems. The medical field began using AI when MYCIN, a pioneering expert system, was developed in the 1970s to diagnose bacterial infections and propose treatments based on fixed rules [14]. Despite their initial role in medical applications, these early systems presented restricted capabilities regarding system adjustability and growth potential.

Machine learning revolutionised the industry when healthcare systems shifted from rule-based systems to data-driven computational approaches. Expert systems in traditional programs required human experts to convert clinical knowledge into decision trees until machine learning, particularly deep learning, enabled computers to learn from large datasets and achieve increased accuracy and flexibility over time [9]. Modern AI systems developed using the foundation established through this fundamental shift from rule-based systems to data-driven strategies, enabling computers to execute advanced operations such as image recognition, natural language processing, and predictive analytics.

Research in this field has achieved several significant milestones over the past twenty years. Medical image analysis experienced a breakthrough with the advent of deep neural networks, which led to the development of convolutional neural networks (CNNs) that outperformed traditional methods in the fields of radiology and dermatology [10]. Medical practitioners now receive evidence-based point-of-care suggestions through AI-based systems embedded in clinical decision support systems (CDSS), as described by Sutton et al. [15]. The healthcare sector shows increased confidence that AI represents a collaborative force in medical decision-making, extending beyond its basic computational capabilities.

As technology advanced, regulatory authorities began to show an equivalent level of interest. In 2021, the U.S. Food and Drug Administration received over 100 medical device submissions incorporating AI or machine learning elements [16].

The number of submissions to regulatory bodies reflects the dual forces of innovation and regulatory necessity in monitoring the safety profiles of AI tools.

Academic and professional institutions have shown an increasing interest in AI-based applications. Research on AI in medicine has shown a rapid growth of medical publications from 2018 onward, addressing various medical specialties, including oncology, cardiology, and neurology [12]. Research on AI in medical applications continues to expand rapidly because of its rapidly developing role in healthcare experimentation and clinical use.

The progression of AI in medicine, from expert systems to modern machine learning, demonstrates a continual advancement of technology, with an increasing number of medical institutions adopting its use and enhanced monitoring from scientific organisations and regulatory bodies.

3.2. AI in Medical Imaging and Diagnostics

Medical imaging and diagnostic medicine are fundamentally transforming through Artificial Intelligence (AI) because it produces technology that detects, classifies, and interprets medical information at high speed and exceptional accuracy. AI's ability to identify patterns and analyze images through automated processes is now indispensable across the radiology, pathology, dermatology, and ophthalmology medical fields [2, 3]. These technologies assist medical professionals while simultaneously yielding better results than human beings in specific diagnostic processes that involve large datasets or delicate image characteristics.

Radiological analysis using AI systems with CNNs can detect medical abnormalities in X-ray, CT, and MRI images, including tumors, fractures, and hemorrhages [10]. The training process of these algorithms relies on thousands of tagged images, through which they acquire diagnostic knowledge to deliver accurate results. AI systems have been used to identify lung nodules through chest radiographs and early-stage breast cancer through mammography, with diagnostic results comparable to those of experienced radiologists [9].

The field of Dermatology benefits largely from AI applications. Artificial intelligence technology examines dermoscopic images to identify melanoma and other skin cancers during their early stages of development. Recent research has shown that medical AI diagnostics outperform human dermatologists in accuracy, particularly in identifying hazardous lesions [3]. Such tools demonstrate special effectiveness in primary care services and underserved geographical areas that lack dermatology specialists.

The application of AI in pathology utilises automated cell diagnosis, enabling pathologists to detect cancer cells within tissue samples more effectively. Digital pathology systems equipped with AI technology can examine and analyse entire digital slide images to identify precise histological findings, thereby enabling doctors to confirm medical diagnoses more accurately and reduce errors [2]. AI technology examines retinal images for diabetic retinopathy, age-related macular degeneration, and glaucoma, enabling early diagnosis before patients require medical attention [1].

According to study findings, multiple investigations have demonstrated that AI systems produce results that compete with or surpass those of human specialists. Studied cases demonstrate that AI models match or outperform human specialists, particularly when utilising well-organized datasets in controlled settings, according to Dodda et al. [10]. Healthcare facilities must validate these techniques in various medical settings and patient populations before AI can be successfully adopted for clinical use due to demands of reliability and generalizability.

AI diagnostics serve broader purposes than performance assessment. They solve healthcare system problems related to workload distribution, speed up diagnosis procedures, and enhance access to services. According to Dixon et al. [5], through AI-automated diagnostic imaging analysis, specialists achieve both workload reduction and faster diagnosis times by delivering remote services. These solutions are essential in resource-constrained settings as they address the gaps left by unavailable specialists.

Doctors and medical institutions now benefit from AI-based diagnostic tools that deliver improved accuracy, efficiency, and accessible diagnosis. Although validation and integration hurdles, alongside regulatory requirements, persist, AI diagnostic applications continue to demonstrate increasing use and practical applications in clinical settings.

3.3. AI in Predictive and Personalized Medicine

The healthcare industry uses Artificial Intelligence to transform from traditional reactive practices to separate categories of proactive, predictive, and personalised approaches. Big data mining through AI enables healthcare professionals to analyse genomic sequences in conjunction with proteomic profiles, electronic health records (EHRs), and lifestyle records to make patient-specific disease risk predictions, leading to more effective treatment solutions [1, 4].

AI algorithms identify high-risk individuals through process-based techniques that traditional statistical analysis cannot recognise. Machine learning models utilise clinical, behavioral, and genetic data variables to predict the development of diseases, including diabetes, cardiovascular conditions, and cancer [5]. Deploying early warning systems enables patients to take preventive steps and create customised medical plans, leading to superior long-term results at reduced costs.

The implementation of artificial intelligence is poised to be an industry-transforming force in personalised medical care. The analysis of genetic mutations using AI systems enables the development of therapy recommendations tailored to the specific tumor profiles of individual patients in oncological treatment [9]. Due to this application, precision medicine treatments yield more effective results with fewer negative impacts. Researchers utilise AI tools for pharmacogenomics applications, which help determine drug reactions in conjunction with the necessary dosage levels and identify side effects triggered by genetic variants [1].

Moreover, AI facilitates continuous monitoring and adaptive care. Health wearables that utilise AI monitoring platforms track patients' biological indicators, enabling doctors to observe disease progression patterns and make real-time adjustments to treatment plans. The applications demonstrate an advantage in managing hypertension, asthma, and diabetes since continuous patient-specific assessment is necessary for achieving effective treatment outcomes [5].

AI technology greatly benefits the discovery process of biomarkers. AI systems analyse extensive biological data to identify new biomarkers that can predict diseases and treatment outcomes. Biomarker discovery through research opens up new opportunities in tailored care systems, which utilise personalized treatments for patients with specific biomarker indicators [4].

Progress has been made in developing predictive and personalised AI models, although several obstacles remain in their practical application. AI models face hurdles, including difficulties in making data interact with each other and clearly demonstrating how algorithms work, as well as seamless integration in practical workflow environments, which can potentially have negative consequences for reducing health equity when training materials are not inclusive [7, 11]. All substantial barriers must be properly addressed to achieve the maximum potential of AI-powered precision medicine.

3.4. Natural Language Processing in Healthcare

The Artificial Intelligence subfield of Natural Language Processing helps healthcare systems today by enabling machines to understand, process, and generate human language content. Vital medical information is extracted from unstructured healthcare documentation, including electronic health records (EHRs), clinical notes, pathology reports, and discharge summaries, through NLP-enabled technologies in clinical environments [15]. Structured data transformations enabled by NLP technology enable medical establishments to obtain efficient information retrieval while improving healthcare decisions and supporting system interoperability.

Medical documentation benefits significantly from NLP systems as a main application. Real-time speech-to-text functionality, developed with AI technology, enables physicians to automatically document patient interactions, prioritising patient care over administrative tasks [17]. The applications offer improved workflow performance while enhancing the precision and completeness of medical records.

NLP is a fundamental component of clinical decision support systems (CDSS). Large clinical text analysis with NLP finds essential patient data for healthcare alert generation and recommendation delivery [15]. NLP extracts information about allergies, comorbidities, and medication risks from unstructured text entries that EHR systems cannot automatically detect.

Information extraction through NLP serves dual purposes for research investigations and public health surveillance monitoring. NLP models process extensive medical data to find disease developments, drug treatment values, and medication side effects [18]. The real-time deployment of NLP tools analysed social media, clinical data, and news publications to identify COVID-19 symptoms and monitor outbreaks, according to Antoniadi et al. [19].

Virtual health assistants and chatbots can apply NLP to offer healthcare responses, manage patient appointments, and provide symptom triage capabilities. Conversational agents created using NLP methods enhance health information delivery and patient engagement systems, particularly for populations in underserved areas [19].

Due to its inherent strengths, the implementation of NLP in healthcare encounters various obstacles. Text processing becomes complicated in the medical field due to specialised terminology, which includes abbreviations, misspellings, and unique healthcare-specific expressions in clinical narratives [18]. Healthcare applications of NLP must address issues related to data privacy, algorithm transparency, and linguistic bias to ensure ethical deployment.

The growth of digital health data necessitates the integration of NLP into healthcare systems to maximise the value of unstructured clinical information and advance patient care customisation, ultimately enhancing the quality of medical services.

3.5. AI in Surgery and Robotics

Surgical procedures now incorporate Artificial Intelligence (AI), robotics, and AI systems to restructure procedure planning while enhancing operational performance and integrating clinical data evaluation. The real-time data processing and machine precision capabilities inherent in AI-powered robotic systems enable precise surgical outcomes, decrease complications, and facilitate individualised operative plans [9]. Minimally invasive surgery and complex procedures benefit most from these technological advancements because they require absolute precision in addition to adaptability.

Robot-assisted surgery represents a significant advancement in this medical field. The da Vinci Surgical System utilises AI algorithms to assist in stabilising surgical movements, delivering 3D magnified imaging, and enhancing surgical instrument dexterity [4]. Such medical technology enables surgeons to perform complex procedures by making small surgical incisions, thereby achieving shorter hospital stays and speeding up patient recovery times, resulting in less medical trauma.

AI technology serves two essential functions before surgery and throughout surgical procedures. By reviewing patient-factual data that includes 3D imaging, anatomic templates, and prior surgical reports, AI systems enable doctors to identify optimal cut positions, predict potential medical issues, and tailor operations to match each patient's unique body structure [5]. AI systems operate during procedures to monitor surgical implement positions simultaneously with error detection features and real-time plan execution monitoring.

AI-powered robotics demonstrate the best potential through neurosurgical and orthopedic surgical procedures. Real-time image analysis with machine learning algorithms enables these systems to position surgical instruments with nanoscopic level precision, thereby improving outcomes during spinal fusion, joint replacement surgery, and brain tumor resection [9]. AI algorithms aid in evaluating surgical behavior, thereby enabling improved surgical quality through structured training programs [18].

Integrating artificial intelligence with augmented reality (AR) and virtual reality (VR) enables the use of simulation and in-operation visual tools in surgical procedures. The tools combine immersive environments, allowing surgeons to practice before operations and navigate during procedures, thereby decreasing surgeon workload and increasing patient safety [19].

Despite these benefits, challenges remain. The high implementation expenses, specialist training requirements, and inaccessibility to substantial randomised clinical tests are preventing broad-scale implementation. Implementing AI systems necessitates the establishment of responsible ethical liability standards and algorithm transparency rules, as AI systems now play a crucial role in managing critical decisions in surgical procedures [20].

The integration of AI with robotic surgery represents a significant advancement in precision medicine and data-driven healthcare approaches. To complete the revolution in healthcare transformation, researchers must conduct sustained studies, medical professionals should actively participate, and effective ethical oversight mechanisms should be established.

3.6. Clinical Decision Support Systems (CDSS)

Clinical Decision Support Systems (CDSS) represent the most influential AI applications in healthcare. They aim to deliver time-sensitive, evidence-based guidance to healthcare providers during clinical decision-making processes. The systems utilise AI algorithms to analyse patient data while integrating medical expertise, thereby supporting healthcare providers in addressing complex diagnostic, therapeutic, and prognostic challenges [15].

Modern CDSSs are integrated into electronic health record (EHR) systems, which can provide precise, real-time recommendations, alerts, and treatment suggestions [17]. AI-enhanced CDSS utilises structured and unstructured clinical data, including test results, image studies, and physician documentation, to reduce diagnostic errors and enhance resource management for healthcare institutions that provide standardised patient care.

CDSS tools demonstrate their effectiveness through essential functions that automatically identify adverse drug interactions while simultaneously alerting contraindications and generating high-risk patient predictions using predictive models [21]. The new system's capabilities optimise patient safety while reducing medical workload, particularly in emergency departments and intensive care units.

Explainable AI (XAI) significantly improves CDSS technology by enabling clinicians to understand the reasoning behind AI-derived clinical recommendations. The efficient delivery of clear explanations fosters trust among healthcare providers, enabling collaborative decision-making and promoting full organisational accountability [19]. The lack of explainable features can make healthcare providers cautious about trusting CDSS outputs, thereby limiting their practical use.

CDSS systems encounter multiple difficulties during the implementation period. Healthcare professionals face challenges in implementing AI-generated suggestions due to privacy issues within data systems, conflicting system integration requirements, excessive alerts, and professional doubts about the reliability of AI suggestions [17, 15]. Numerous CDSS systems lack sufficient clinical evidence of their effectiveness, and research reveals conflicting data regarding their impact on patient health outcomes [22].

CDSS achievement relies on joint development with healthcare providers, comprehensive testing, and customization tailored to specific clinical use environments. These systems require continuous maintenance to deliver new clinical standards, utilising genuine practitioner insights to preserve their accuracy and sustained value.

AI-based CDSS demonstrates remarkable potential to improve healthcare quality while enhancing safety and delivery efficiency in patient care. CDSS success requires proper planning, doctor participation, and strong administrative systems that address operational and ethical concerns.

3.7. AI in Drug Discovery and Development

Artificial Intelligence advancements accelerate research durations and enhance laboratory operations' cost efficiency while increasing the likelihood of successful clinical trials. The current pharmaceutical development process typically takes around ten years to complete, with costs exceeding billions of dollars, and exhibits high failure rates during clinical testing stages. According to Serrano et al. [9] and Niazi [16], AI tools facilitate the identification of promising drug candidates, combined with the prediction of molecular behavior and the enhancement of trial design.

The main advantage of AI technology for pharmaceutical research lies in its ability to detect and authenticate drug targets. According to Serrano et al. [9], artificial intelligence algorithms track disease-related molecular targets by evaluating genomic and proteomic datasets alongside chemical datasets. Exploring hidden patterns through machine learning models yields suggestions of new target possibilities that human evaluators cannot detect with conventional approaches.

AI has transformed the process of creating new drugs from scratch. Combining deep generative networks and reinforcement learning algorithms enables the development of new molecular structures with preferable characteristics while shortening the synthesis and screening procedures [10]. The multi-parameter evaluation of algorithms for drug candidates succeeds in generating improved drug candidates because it analyzes potency in conjunction with bioavailability and toxicity.

Drugs undergo repurposing with the help of AI technology when researchers search for new medical applications of currently available pharmaceutical products. Artificial intelligence analyses clinical trials, medical literature, and real-world health records to produce a method for detecting drug-to-indication recommendations that enhance pharmaceutical market entry [9].

The clinical trial process benefits from AI by utilising it to select the appropriate patient groups, calculate trial participant dropouts, and monitor continuous trial data analysis for safety alerts [16]. The data-driven method maximises operational efficiency by reducing costs and improving ethical compliance, thereby limiting patients from receiving ineffective treatments.

The progress in drug development through AI technology does not eliminate the existing difficulties that emerge with its implementation. The integration of AI in drug development faces barriers from diverse clinical datasets, undefined procedural guidelines, and regulatory ambiguity. The FDA and other regulatory bodies have expressed concern about the interpretability of AI-generated drug candidates, as such drugs must meet stringent safety standards [16].

The drug discovery pipeline undergoes significant enhancements through the application of AI as it progresses from the design to the clinical validation stages of drug development. To ensure responsible drug testing, the following stages of AI drug development must be supported by regulatory guidelines, multidisciplinary teamwork, and ethical governance.

3.8. Ethical and Legal Implications

Healthcare organisations must address profound ethical and legal issues arising from implementing Artificial Intelligence (AI) systems to ensure safe practices and equitable distribution of resources. When fully implemented, Artificial Intelligence demonstrates potential for improved efficiency and outcomes, but simultaneously creates challenges related to patient privacy protection, data security, algorithmic bias, transparency issues, accountability frameworks, and the strengths of existing legal frameworks [7, 6].

The safeguarding of patient data is a major ethical concern affecting healthcare today. The operations of AI systems heavily depend on large datasets that contain electronic health records (EHRs) and genetic profiles, along with clinical images, which comprise sensitive, personally identifiable information. To sustain patient-provider trust, healthcare organisations must safeguard data confidentiality, integrity, and proper usage [20]. The General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA) establish fundamental data protection standards; however, emerging technologies necessitate more robust adaptive models of data governance control.

The central ethical issue arises from biases that can appear in algorithms. AI systems yield discriminatory outcomes because their training data often lack sufficient representation of the patient population and diversity, leading to biased results. Existing health inequalities between patient groups are exacerbated because disparities worsen for underrepresented populations [11, 6]. Before deploying AI systems, organisations should develop ways to examine their fairness characteristics and conduct tests involving diverse patient populations.

For clinician and patient trust to develop properly, the systems must feature transparency and explainable functionalities. Advanced AI systems with deep learning components operate as opaque entities, as their decision-making processes remain unrevealed. The absence of explainability prevents clinical personnel from adopting AI solutions, as such systems become difficult to account for in reactions to adverse results [18]. Explaining the reasoning behind AI outputs forms the core of XAI, which focuses on human interpretation in critical diagnostic and treatment planning applications [19].

AI in healthcare presents numerous legal complexities which need careful examination. Legally establishing responsibility for medical errors involving AI systems remains an unresolved issue, as courts must determine which portion of the mistake falls under the control of the AI system. The introduction of AI complicates the traditional legal assignment of responsibility, as the technology introduces intricate layers of automation that create significant challenges for holding entities accountable [6]. When AI recommendations cause harm, what role should doctors, developers, or healthcare facilities exercise in handling such instances? The absence of clarity necessitates the development of precise regulatory structures that define duties while establishing control systems and complaint procedures.

The extensive healthcare potential of AI technology necessitates that society prioritise its ethical considerations and address legal compliance issues. To provide meaningful benefits to all healthcare stakeholders, the ecosystem requires proactive actions that combine ethical audits with regulatory reforms, algorithm transparency and the inclusion of diverse data practices.

3.9. AI and Global Health

The transformative power of Artificial Intelligence helps reduce global health differences, especially in low-resource healthcare nations (LMICs) with inadequate medical structures. AI technology's capabilities to create scalable, cost-effective, and high-matched solutions enable better disease monitoring, enhanced diagnosis accessibility, and service delivery excellence for underserved communities [2, 4].

AI brings the most significant impact to global health through its capability to develop automated diagnostic systems. AI-based mobile health (mHealth) applications, combined with point-of-care devices, facilitate the early detection of tuberculosis, malaria, and diabetic retinopathy, eliminating the need for continuous medical specialist availability [3]. The tools benefit rural settings specifically because health experts are limited and patient health services remain difficult to access.

The application of AI plays a major role in both epidemiological studies and pandemic management strategies. The COVID-19 pandemic enabled AI to forecast disease progression, monitor public health patterns, and efficiently allocate resources [5]. Youths, news sources, and healthcare databases provided real-time information to machine learning techniques, which identified active outbreak areas and facilitated risk evaluations, aiding in developing containment solutions. The applications suggest that AI is vital for both proactive health management and global crisis response.

AI technology enables remote healthcare services which combine patients from remote areas with medical physicians through enhanced digital platforms. Such platforms evaluate patient conditions, prescribe suitable treatments, and establish medical-grade classifications for different cases, thereby extending healthcare service delivery while reducing pressure on operational healthcare systems [4].

Healthcare supply chain management profits greatly from AI applications. Predictive analytics systems determine the quantity of essential medicine supplies needed, the amount of vaccine supply, and the necessary equipment to prevent supply chain issues. Such a resource management strategy ensures precise distribution during standard care activities and urgent situations [2].

Implementing AI in global health faces numerous obstacles despite demonstrating value to its users. Implementing effective programs faces hindrances due to digital infrastructure deficits, as well as concerns about data privacy and algorithmic bias, and the scarcity of local healthcare experts [23]. The data training of numerous AI tools occurs in high-income nations, which raises concerns about their suitability and fairness for populations with diverse cultural backgrounds worldwide.

To achieve balanced outcomes, AI applications in global health require team-based system development, standardised personnel training, and international partner collaboration. The healthcare priority needs to focus on creating AI systems that accommodate medical requirements while implementing ethics guidelines to establish proper medical AI system deployment and developing frontline medical staff training.

3.10. Challenges and Limitations of AI in Medicine

Under current circumstances, AI enables a complete transformation within medical care; however, technical barriers, ethical guidelines, and management challenges hinder its full implementation across healthcare structures. AI systems require the resolution of technical and operational barriers and ethical and regulatory challenges before achieving identical deployment standards that ensure safe implementation in clinical environments.

Data quality defects, along with interoperability issues, constitute the most significant technical hurdles. Correct AI outputs depend on large datasets that need to include diverse, high-quality information. Healthcare data exists in separate parts, resulting in variable format patterns that hinder collaborative data integration between institutions [5]. The combination of standardised data governance standards and data silos hampers complete patient record processing by AI systems thus reducing both model performance and possible applications.

The biggest drawback of the AI algorithm design is the absence of clear documentation for processes and unclear system operations. The decision-making processes of most advanced models, including those based on deep learning, remain opaque due to their black-box properties [18]. Unclear algorithm operations deter doctors from using these devices, particularly when making critical patient decisions, as they require a clear understanding and full accountability [19].

Algorithmic bias presents a significant challenge to this system's most fundamental functions. AI systems produce biased results due to their training on limited and non-representative datasets, which creates unfair diagnosis methods and treatment delivery systems [11]. Reality-based dataset training excludes population minorities, which leads to worse accuracy predictions for minorities and thus enhances preexisting healthcare inequalities.

Medical professionals who decline to adopt AI and those with inadequate training create challenges that must be addressed. To effectively implement AI tools, medical groups must modify their workflow systems and decision-making processes. Healthcare practitioners frequently doubt collaborating with AI systems, as they often have limited practical experience and remain uncertain about system reliability, particularly when digital tool training lacks substance [23].

The unclear regulatory frameworks governing medical accountability create obstacles for healthcare regulatory authorities to effectively utilise AI technologies in their operations. There is a lack of clarity regarding which actor, developer providers or medical professionals, will take legal responsibility when an Artificial Intelligence system fails to deliver correct services. The medical liability laws currently in use are insufficient to address the complex problems that arise when using autonomous and semi-autonomous AI systems [6].

AI systems pose substantial risks due to their increasing dependency on medical practice. The use of AI outputs that go beyond their intended boundaries and insufficient critical oversight leads clinicians to waste their clinical evaluation abilities and judgment capabilities. Patient care quality and safety suffer important consequences in the long run because AI delivers results that are either wrong or insufficient [19].

Medical AI innovations require effective limitation management, enabling stakeholders to reap maximum benefits while ensuring safe deployment. Trustworthy AI-assisted healthcare requires clear algorithm design, comprehensive medical staff training, legal revisions, and ongoing ethical review protocols.

3.11. Review of Relevant Theories

Medical professionals require conceptual frameworks to comprehend the application of artificial intelligence in medicine, encompassing adoption processes, dissolution frameworks, and ethical management systems for new medical technologies. The medical healthcare sector needs multiple theoretical frameworks to analyse system implementation processes, user acceptance patterns, and regulatory framework requirements.

People choose to adopt new technologies based on two key evaluations: ease of use and practical usefulness, which follow the principles of the Technology Acceptance Model (TAM) [24]. TAM is the necessary framework to explain the factors that encourage healthcare providers to adopt or reject AI-based medical tools in their professional activities. Research indicates that medical staff are hesitant to adopt accurate AI systems, as they find AI technology challenging to implement and potentially disruptive to their existing medical protocols [19, 23].

The Diffusion of Innovations Theory received key attention from Rogers [25] in his work. New technologies spread across social structures through the theory, while adopting determinants such as relative advantage, compatibility, complexity, trialability, and observability help to explain this process. The adoption rate of AI tools in healthcare increases when these tools present clear advantages to patient care, align with existing operational frameworks, and garner peer recommendations [9].

According to the Socio-Technical Systems Theory, technology relies on its social operating context for its functionality. The framework presents suitable applications in healthcare because AI systems need to operate within complex networks, which include patients, clinicians, administrators, and policymakers. The key to achieving successful AI implementation involves combining technical capabilities with assessing social dimensions, organisational structure, and ethical requirements [18].

The normative framework for evaluating AI applications in medicine originates from Principlism, which is grounded in the principles of autonomy, beneficence, non-maleficence, and justice [26]. The principles facilitate the evaluation of safe and equitable decisions established through AI technology, particularly when patient privacy rights and issues with algorithmic bias arise [20, 6].

Health law frameworks which determine accountability and liability responsibilities have gained increasing importance. These accountability systems determine liability for medical mistakes that stem from AI systems. AI systems are gaining greater autonomy, prompting legal theories to examine how developers and healthcare institutions share responsibility with end-users [6].

These theories provide a comprehensive foundation that helps experts understand all dimensions of AI medicine adoption challenges. User perception, combined with systemic compatibility, social dynamics, ethical values, and legal responsibility, guides the pathway of AI-enhanced healthcare development.

3.12. Theoretical Implications

The medical practice's implementation of Artificial Intelligence (AI) introduces system improvements and conceptual challenges to health informatics frameworks, medical ethics, and organisational behavioral frameworks. The rapid implementation of AI systems in healthcare operations necessitates the evolution of existing theories to accurately depict the relationships between humans, technology, and structure.

The existing TAM framework requires modification to integrate trust metrics and explainable features, as these elements are critical for AI-driven healthcare operations in critical medical decisions [18, 19]. Research on the Technology Acceptance Model (TAM) and hybrid models should integrate both ethical perception measures and assessments of cognitive workload, as well as autonomy perceptions from healthcare providers, in their development.

Health service adoption patterns indicate that the Diffusion of Innovations Theory applies to the dissemination of AI technology, as patient perceptions of technology align with institutional readiness and policy frameworks, as well as cross-disciplinary collaboration [9]. AI implementation necessitates substantial changes to interconnected systems, extending beyond medical standards, as the process simultaneously affects data systems, legal structures, and clinical operational culture.

The medical field requires ethical oversight to evaluate the application of the Principlism framework in conjunction with artificial intelligence in clinical practice. New non-human decision-making inputs present barriers to applying the principles of autonomy, beneficence, non-maleficence, and justice, as per Beauchamp and Childress [26]. Protecting patient autonomy becomes challenging for healthcare providers because they must balance protecting patient decisions, yet algorithm suggestions often lack clarity, and systems exhibit training biases [11].

The AI era elevated the Socio-Technical Systems Theory to increased significance. The Theory provides healthcare organisations with a comprehensive understanding of how adopting artificial intelligence modifies roles and advancements between personnel, technological systems, and workflow processes [18]. Collaborative system development methods involving medical staff members, patients, and Technology Information experts are necessary.

Studies regarding legal responsibility require updates, as AI decision-making processes require legal recognition. Current professional responsibility theories fail to address fully vital moral agency questions regarding liability in the face of this technological challenge [6].

The medical integration of artificial intelligence possesses practical functionality while necessitating theoretical advancements of essential concepts and model development. Future research should develop innovative academic theories that address AI's distinct socio-technical and ethical aspects in medical practice.

4. Future directions

Artificial Intelligence (AI) is transforming modern medicine through technological progress, but future development requires attention to both operational and ethical and legal obstacles that will arise with broad-based implementation. The complete realisation of artificial intelligence's potential needs an organised multidisciplinary strategy aligned with fair healthcare distributions and transparent operations that advocate sustainability in worldwide health systems.

The future development imperative focuses mainly on creating explainable Artificial Intelligence (XAI) systems. Modern AI systems operate with black-box interiors, which decreases professional trust and affects regulatory inspections. Research-developed interpretable model outputs will enhance decision-making workflows, as these outputs improve both clinician comprehension and user confidence [18, 19].

According to Challen et al. [11], AI developers must concentrate on ethical methods for designing and deploying AI systems to lower algorithmic bias. Future research must also concentrate on developing datasets that include all healthcare settings and diverse patient populations. Equity-aware AI initiatives serve as vital measures to ensure fair treatment outcomes while preventing the continuation of existing healthcare disparities [7].

AI will extend its health applications globally. Mobile diagnostics, combined with remote triage systems and disease surveillance platforms, will help reduce healthcare gaps in low-resource environments to achieve universal health coverage, according to Walsh et al. [23] and Goisauf and Abada [4]. The design of scalable, sustainable solutions requires joint efforts between developers of AI systems and stakeholders from global health institutions in partnership with local community members who understand their specific context.

The regulatory sector needs to develop adaptable legal and policy frameworks that can respond to changes in AI technology. The development of AI-assisted healthcare necessitates clear liability definitions to support medical care, while industries must establish algorithm testing protocols and protect patient rights across multiple jurisdictions [6]. International partners must collaborate to establish global guidelines on AI ethics in healthcare systems.

Medical education requires the integration of AI disciplines to achieve long-term, positive effects through education. Medical schools should integrate data literacy, ethical modules, and human-AI teamworking components into their educational programs to train future healthcare providers to operate with AI systems effectively [23]. Proactive training will produce healthcare professionals with strong capabilities in using AI tools while maintaining ethical responsibility.

Different research groups with diverse backgrounds must continually study to refine theoretical models and provide evidence-based policy directions. The satisfaction of human-centered healthcare relies on complete knowledge about AI autonomy, together with its modern technology-age social effects and moral constraints.

The future development of AI medicine depends on technological progress, purposeful medical system design, and necessary regulations. Patient-oriented educational programs that aim for social welfare should also be offered.

4.1. Longitudinal Studies

The development of Artificial Intelligence requires healthcare research using longitudinal analysis, as it reveals key details about long-term effectiveness and safety, as well as the social effects. Extended longitudinal observational studies enable researchers to track nationwide AI interventions, allowing essential information collection about clinical patient outcomes and healthcare system outcomes and expenses, including productivity metrics affecting patient happiness rates.

The longitudinal research design gives investigators an advantage for determining the practical operating period of AI systems and measuring their adaptive capabilities. Serrano et al. [9] define data drift as the phenomenon where recorded data patterns and practices change, as well as fluctuations in patient statistics, leading to diminished AI algorithm performance in standardised tests. The length of evaluation activities supports clinicians in finding opportunities to retrain or recalibrate their models for maintaining precise performance in healthcare environments that change over time.

Results that affect patients must be evaluated by the essential elements of research investigations. Research on AI tools applied to chronic disease care with predictive analytics must demonstrate consistent patient benefits, including reduced hospital admissions, while improving quality of life and medication adherence [5]. The extended collection period of longitudinal data enables complete accuracy in analysing long-term medical results that cannot be verified through brief testing periods.

Scientists conduct extensive research to observe how doctors utilise AI system recommendations in their practice and the effects their adoption of these recommendations has on professional activities and healthcare processes. Evaluating sociotechnical patterns surrounding AI implementation demands such insights to safeguard against inputs that limit medical staff control and deteriorate patient-focused treatment [23].

Longitudinal research allows researchers to monitor essential ethical and legal aspects, which cover patient privacy maintenance alongside bias framework assessment. The prolonged implementation of AI systems creates unknown impacts, as particular population groups may face systematic biases after extensive use has begun [11, 7].

Longitudinal AI studies face multiple barriers in their development, primarily due to funding limitations and challenges in obtaining data and meeting regulatory requirements. The stand-alone development systems for AI tools lack long-term assessment features because they do not perform regular operations at the required levels. New research projects should focus on extensive, multi-year studies conducted across various clinical sites and comprehensive patient demographics to achieve more accurate generalisation results for AI regulation.

Longitudinal studies enable healthcare to move from proof-of-concept evidence to sustainable AI integration in medicine based on well-established data. Such research yields deep analytical insights that enable the assessment of AI performance, including its effectiveness and impact on specific patient groups under various circumstances.

4.2. Intervention Studies

Healthcare practitioners must conduct intervention studies to measure AI applications' performance and safety outcomes in clinical care. The research utilises specific healthcare environments to deploy AI systems, allowing for the assessment of their effects on healthcare delivery, clinical operational procedures, and physician decision support capabilities. Researchers can demonstrate how artificial intelligence affects health outcomes across various operational settings through actual implementation experiments.

Intervention studies excel at determining the practical value which AI tools offer to clinical applications. Researchers assess AI systems' actual diagnostic and therapeutic value for healthcare outcomes by conducting prospective trials based on real-world clinical interventions [9, 5]. Testing has shown that AI systems used in radiology practice can help medical staff detect breast cancer and pneumonia with improved accuracy and reduce diagnostic errors in clinical environments [2].

The impact of AI on healthcare efficiency and resource allocation assessment is examined through intervention research studies. Healthcare institutions have implemented AI-based frameworks that enhance operating room scheduling, predict patient deterioration, and automate administrative tasks, thereby minimising waiting times, reducing hospital admissions, and reducing clinician workload [17]. Assessing direct and indirect AI implementation benefits through properly developed interventions enables health systems to measure these outcomes effectively.

Studies of intervention function as an approach to studying the interaction dynamics between human users and AI systems. AI systems remain useful support tools in clinical practice when dynamic relationships between AI tools and clinicians achieve effective implementation success.

The implementation of AI intervention research becomes complex because it encounters crucial barriers during execution. Evaluating different technological implementations becomes complex due to a lack of standardisation practices, which affects brief observation periods and difficulties promoting random participant exposure to AI systems [18]. Deploying AI interventions requires thoroughly evaluating patient ethical concerns and comprehensive security measures to ensure data protection and fair algorithm functioning [20].

Research studies that aim to build evidence foundations for the future should rely on randomised controlled trials (RCTs) combined with stepped-wedge designs and mixed-methods approaches as their strong research methodologies. The effectiveness of AI solutions needs to be tested through decision-making investigations across all population segments in diverse healthcare settings to ensure equal beneficial results.

Research interventions represent vital steps for converting AI breakthroughs into practical healthcare. Healthcare leaders obtain necessary evidence to determine AI implementation and spread through these practical results, which connect technical capabilities to real-world outcomes.

4.3. Ethical Frameworks

Adopting Artificial Intelligence in healthcare demands complete ethical guidelines to establish creation processes, system implementation procedures, and supervision protocols. Artificial intelligence's great power to enhance healthcare operations and diagnostic precision has created numerous complex moral issues for patients, particularly concerning their autonomy, as they seek favorable outcomes that help prevent harm while balancing administrative responsibilities. A solution to these problems requires the implementation of both traditional bioethical principles and modern ethical systems that specifically analyse artificial intelligence.

The foundational assessment elements for medical ethical evaluations derive from Principlism to evaluate how AI should be used in medical practices. The bioethical framework of Beauchamp and Childress [26] establishes four core principles that unite support for patient self-regulation with beneficial healthcare treatment while eliminating potential harm and prohibiting unethical procedures for all medical users. Malfunctions in AI systems pose two types of autonomous breaches: hidden algorithm processes and harmful results stemming from biased data and unverified AI models [18, 20].

New thinking approaches implemented today alter traditional ethical frameworks to fulfill intellectual needs in artificial intelligence domains. Explainable AI (XAI) has emerged as a solution for transparency and interpretability, as both aspects are crucial for respecting patient and clinician autonomy [19]. Insufficient explainability prevents patients and providers from understanding AI recommendations, impeding their ability to challenge or override these suggestions, affecting their informed consent and decision-making process.

Contemporary ethical frameworks prioritize fairness and inclusivity as primary concerns regarding algorithms. Computer systems based on non-diverse training data tend to generate unfair outcomes that mostly affect minority social groups. The World Health Organization (WHO) supports ethical frameworks that require developing AI systems that incorporate equity principles during their design and implementation processes [28].

The emerging approach to AI accountability, along with AI responsibility, seeks to establish clear liability boundaries when AI systems yield harmful outcomes. Traditional legal systems and ethical models prove insufficient for analysing autonomous and semi-autonomous systems that operate with partial automation. A growing consensus in ethics and regulatory circles involves establishing shared responsibility among clinical staff, IT developers, and healthcare institutions [6].

Participatory ethics is a vital element that must be considered. The method requires the active involvement of healthcare professionals, patients, ethicists, and technologists during the AI system design phase and its deployment stage. AI tools that integrate multiple stakeholder views from the outset of creation tend to align with social standards while meeting practical healthcare needs, which leads to broader public acceptance [4].

Ethical AI medical frameworks must be developed from traditional, fixed principles to models that handle technological intricacies, adapt to social differences, and provide instantaneous decision systems. Above all, the responsible implementation of AI in healthcare requires medical staff from different fields to collaborate with patients while maintaining transparent systems, fair practices, and responsible accountability measures.

5. Discussion

5.1. R1: How has AI evolved in the field of medicine, and what are the key milestones in its development?

AI in medicine has evolved significantly from early rule-based systems like MYCIN to contemporary models powered by deep learning and big data analytics. Early systems were limited by rigid logic and lack of adaptability. Still, recent advancements—such as convolutional neural networks (CNNs), natural language processing (NLP), and generative AI—have enabled the automation of complex clinical tasks [14, 9]. Major milestones include FDA-approved AI diagnostics, real-time predictive tools, and the integration of AI into electronic health record (EHR) systems [16].

5.2. R2: In what ways is AI currently applied in medical diagnostics, imaging, and clinical decision-making?

Artificial intelligence (AI) is widely utilised in medical diagnostics to aid in disease detection and classification, particularly in radiology, dermatology, and pathology [10]. AI-enhanced imaging systems detect anomalies, such as tumors or lesions, with high precision. In clinical decision-making, AI-driven Clinical Decision Support Systems (CDSS) offer real-time recommendations, flag adverse drug interactions, and guide clinicians toward evidence-based decisions [15]. NLP models extract insights from unstructured data, making patient information more accessible and actionable [17].

5.3. R3: How does AI contribute to personalised and predictive medicine, and what are the implications for patient outcomes?

AI facilitates personalised medicine by analysing genetic, behavioral, and clinical data to recommend individualized treatments [1]. In predictive medicine, machine learning algorithms anticipate disease progression, readmission risk, and patient outcomes. This enables proactive care planning and resource optimisation [5]. The implications are profound: improved therapeutic accuracy, reduced complications, and enhanced quality of life. The role of AI in biomarker discovery and pharmacogenomics further supports the development of tailored therapeutic interventions [9].

5.4. R4: What are the ethical, legal, and regulatory challenges associated with integrating AI into healthcare systems?

The ethical and legal dimensions of AI are central to its responsible deployment. Key issues include data privacy breaches, algorithmic bias, lack of transparency, and ambiguity in liability [6]. Ethical principles, such as autonomy and justice, are tested when AI outputs are unexplainable or yield unequal outcomes across populations [26, 20]. Current legal frameworks often lag behind AI innovations, necessitating adaptive regulatory models that balance innovation and patient safety and rights.

5.5. R5: How can AI be effectively implemented in low-resource and global health settings to address disparities in care delivery?

AI can play a vital role in addressing healthcare inequities by enabling mobile diagnostics, telehealth, and automated triage in underserved regions [4, 3]. AI applications with minimal requirements enable the early detection of diseases and the monitoring of disease occurrence through systems that operate with limited facilities or no internet connections. The success of AI programs depends on adapting systems to local contexts while developing inclusive databases alongside partnerships with local community members to prevent the perpetuation of existing social inequalities [23].

5.6. R6: What are the current limitations of AI in medicine, and what future directions should research and policy focus on to ensure responsible and effective use?

Current limitations include data silos, interoperability challenges, algorithmic opacity, and clinician distrust [18]. There is a lack of longitudinal and intervention studies assessing the sustained impact of AI [9]. Future efforts should focus on developing explainable AI, refining ethical frameworks, and expanding interdisciplinary education and training for healthcare providers [19, 23]. Policymakers must also develop adaptive regulations that define accountability, standardise validation, and promote the equitable integration of AI.

Table 1 Summary of Key Findings

Research Question	Key Findings
R1: Evolution of AI in Medicine	AI has evolved from rule-based systems to deep learning models, with key milestones including the development of CNNs, FDA approvals, and the integration of EHRs [9].
R2: Applications in Diagnostics & Imaging	AI enhances diagnostic accuracy, particularly in imaging and pathology, and facilitates real-time decision-making through NLP and CDSS [2, 15].
R3: Personalized and Predictive Medicine	AI enables individualized treatment and predictive analytics, improving clinical outcomes and preventive care [1, 5].
R4: Ethical, Legal, and Regulatory Challenges	Key concerns include bias, data privacy, explainability, and legal accountability. Current frameworks are insufficient and require adaptation [7].
R5: AI in Global Health	AI enhances access to care in low-resource settings through mHealth tools and remote diagnostics, but it requires localization and implementation of ethical safeguards [4].
R6: Limitations and Future Research	Challenges include a lack of longitudinal studies, algorithmic opacity, clinician resistance, and insufficient regulation. Future research should emphasize equity, explainability, and interdisciplinary collaboration [19, 23].

6. Conclusion

Artificial Intelligence shapes the current medical practice through fundamental changes that transform existing medical systems. The healthcare delivery system can undergo substantial improvements with the use of AI technology, as it enables better diagnostics and individualised treatment and broadens healthcare access to underserved communities. Integrating AI systems presents multiple moral, legal, and operational hurdles that professionals must approach with caution. This paper reviewed the historical evolution of AI in medicine, its key applications, and the barriers to its adoption, offering a comprehensive overview of current trends, theoretical insights, and future directions.

6.1. Call to Action

The future of AI in medicine hinges not only on technological advancements but also on the ethical, legal, and social frameworks that guide its implementation. To ensure responsible, equitable, and effective adoption, the following actions are essential:

- Policymakers must accelerate the development of adaptive regulatory frameworks that address accountability, data governance, and standards for AI safety.
- Researchers should prioritise longitudinal and intervention studies that assess real-world outcomes, particularly in diverse and underserved populations.

- Educators and healthcare institutions must incorporate AI training into medical education, equipping future clinicians with the skills to evaluate and responsibly utilise AI tools critically.
- Developers and AI designers must adopt participatory design approaches, ensuring that systems are transparent, explainable, and inclusive from the outset.
- Global health leaders should invest in scalable, culturally appropriate AI solutions that bridge healthcare gaps and promote universal access.

By advancing AI within a framework of ethics, inclusivity, and evidence-based practice, stakeholders can ensure that this transformative technology delivers on its promise to enhance, rather than replace, human-centered care.

Compliance with ethical standards

Disclosure of conflict of interest

The author(s) declare that there is no conflict of interest.

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