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Artificial Intelligence in Health

MINI-REVIEW

Innovation management for artificial intelligence adoption in healthcare and biopharma: A mini-systematic review

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Abstract

Recent advancements in artificial intelligence (AI) are reshaping core functions within healthcare and biopharmaceutical industries, particularly in diagnostics, personalized care, and drug development. However, the success of these innovations hinges on how well institutions manage their implementation. This systematic review investigates how innovation management influences AI adoption in healthcare and biopharma, highlighting both progress and persistent challenges. Following the preferred reporting items for systematic reviews and meta-analyses guidelines, this review was conducted using literature sourced from five major databases – PubMed, IEEE Xplore, Scopus, Web of Science, and Embase – focusing on peer-reviewed studies published between 2015 and 2024. A total of 82 studies were included, comprising 42 quantitative, 30 qualitative, and 10 mixed-methods studies. The population, intervention, comparison, and outcome framework guided study selection, while quality was assessed using the Joanna Briggs Institute checklist and Cochrane Risk of Bias 2.0 tool. Findings reveal that AI systems enable earlier disease detection, streamline patient triage, and improve operational workflows. In biopharma, companies, such as Moderna have shortened vaccine development timelines by integrating AI into molecular design. However, significant roadblocks remain, particularly regarding data privacy, infrastructure costs, and insufficient AI literacy among healthcare providers, especially in low- and middle-income countries. These barriers underscore the need for proactive innovation management approaches. To promote sustainable and ethical AI integration, this study recommends the development of governance frameworks, targeted workforce training, and increased interdisciplinary collaboration. As AI continues to evolve, managing its adoption thoughtfully will be essential to balancing technological potential with clinical realities and patient-centered care.

Keywords: Artificial intelligence; Healthcare innovation; Biopharmaceutical industry; Innovation management; Artificial intelligence governance; Digital health; Ethical artificial intelligence; Healthcare administration

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1. Introduction

The adoption of artificial intelligence (AI) in healthcare and biopharma is no longer a futuristic vision – it is actively reshaping how clinical and pharmaceutical services are delivered. From enhancing diagnostic precision to accelerating drug discovery timelines, AI has introduced tools that enable more informed and efficient decision-making at both the patient and organizational levels.[1] In an era where health systems are burdened by increasing populations, chronic disease prevalence, and rising demand for personalized care, AI offers scalable, data-driven solutions.[2,3]

Globally, countries are prioritizing investments in AI and digital health systems as part of broader strategies to strengthen health delivery. The Organisation for Economic Co-operation and Development (OECD) reported that nations with robust digital infrastructures were better equipped to manage the COVID-19 crisis, underscoring the importance of digital readiness and adaptability.[4] In low- and middle-income countries (LMICs), AI is being leveraged to close care gaps; for example, portable AI-powered ultrasound devices are improving breast cancer detection in remote African communities.[5]

Rather than remaining limited to rule-based systems, modern AI incorporates advanced machine learning and deep learning algorithms capable of processing vast, unstructured medical data. These technologies are now applied in radiology, early disease detection, predictive analytics, and patient monitoring, supporting clinicians with faster and more precise decisions.[6,7] In the pharmaceutical sector, AI models are reducing research bottlenecks by simulating molecular interactions, identifying viable drug targets, and optimizing clinical trial protocols, thereby compressing drug development timelines.[8]

However, successfully embedding AI into health systems requires more than technological capability. The OECD emphasizes that the main challenges to AI adoption are not purely technical but institutional, regulatory, and organizational.[9] Innovation management plays a pivotal role in ensuring AI integration is ethical, effective, and sustainable. This involves aligning AI development with policy frameworks, governance structures, and organizational readiness.

International organizations are also playing a more active role. The World Health Organization launched the global initiative on AI for Health to establish standards, promote ethical deployment, and guide countries in adopting AI responsibly.[10] The OECD similarly warns that without adequate oversight, AI systems may exacerbate inequality, compromise patient data security, or foster overdependence on opaque algorithms.[4]

Academic perspectives remain divided. While many researchers argue that AI can augment human judgment and enhance health outcomes, others express concern over biased algorithms, lack of transparency, and reduced clinician autonomy.[11,12] These contrasting views reinforce the need for robust governance, ethical foresight, and coordinated innovation management.

This article explores how innovation management can guide the responsible deployment of AI across healthcare and biopharma. By analyzing real-world applications, regulatory implications, and strategic approaches, this review offers practical insights into how stakeholders can align AI advancement with equitable, ethical, and patient-centered healthcare transformation.

2. Methodology

This systematic review was conducted in accordance with the preferred reporting items for systematic reviews and meta-analyses 2020 guidelines to ensure transparency, reproducibility, and methodological rigor in the identification, selection, and synthesis of studies.[13] The study followed a structured process, including the review question formulation, data collection, quality assessment, and findings analysis based on clearly defined criteria.

2.1. Study design

A systematic review approach was adopted to evaluate the role of innovation management in AI development within healthcare and biopharma. The review aimed to identify key strategies, applications, and challenges in managing AI-driven transformation, with a focus on ethical, operational, and regulatory implications.

2.2. Eligibility criteria

The inclusion and exclusion criteria were developed using the Population, Intervention, Comparison, and Outcome framework, which supports the formulation of focused and answerable research questions in systematic reviews.[14] The parameters included were:

(i) Population: Healthcare and biopharma sectors.
(ii) Intervention: Implementation of AI technologies.
(iii) Comparison: Traditional healthcare or research approaches.
(iv) Outcomes: Improvements in efficiency, accuracy, innovation management, and patient outcomes.

2.2.1. Inclusion criteria

The inclusion criteria were as follows:

(i) Peer-reviewed studies published between 2015 and 2024.
(ii) Articles discussing AI applications in healthcare and biopharma.

(iii) Studies addressing innovation management strategies for AI adoption.
(iv) Publications written in English.
(v) Full-text availability.

2.2.2. Exclusion criteria

The exclusion criteria were as follows:
(i) Studies unrelated to AI applications in healthcare or biopharma.
(ii) Articles focusing solely on technical AI algorithms without a managerial or strategic component.
(iii) Non-peer-reviewed literature (e.g., pre-prints, blog posts).
(iv) Conference abstracts without accessible full texts.

2.3. Data sources and search strategy

A comprehensive literature search was conducted across multiple databases, including PubMed, IEEE Xplore, Scopus, Web of Science, and Embase. The search terms included both MeSH terms and free-text keywords, such as "artificial intelligence in healthcare," "AI in drug discovery," "innovation management in AI," "digital health transformation," and "AI governance in biopharma." Boolean operators (AND, OR) were used to optimize and combine search terms. Reference lists of included articles were also manually screened for relevant additional studies.

2.4. Study selection and screening process

All identified articles were screened through a two-step process. First, two independent reviewers examined the titles and abstracts to exclude studies that did not meet the inclusion criteria. Second, the remaining full-text articles were assessed for eligibility. Discrepancies were resolved by a third reviewer. Cohen's Kappa coefficient was calculated to assess the inter-rater agreement during the selection process.

2.5. Data extraction and quality assessment

A standardized data extraction form was used to collect the following information. The extraction form included details, such as study title, author(s), and publication year, AI application domain (e.g., diagnostics, patient care, and drug development), innovation management frameworks or strategies discussed, and key findings, outcomes, and challenges reported.

To evaluate study quality, two established tools were applied: The Joanna Briggs Institute (JBI) Critical Appraisal Checklists and the Cochrane Risk of Bias 2.0 (RoB 2.0) tool. The JBI Critical Appraisal Checklists were used for both qualitative and quantitative studies to assess the methodological validity, relevance, and trustworthiness of the data. The JBI Manual for Evidence Synthesis offers structured guidance for applying these tools across different study designs.[15] The RoB 2.0 tool was used for assessing randomized studies, focusing on bias in randomization, deviations from intended interventions, missing outcome data, outcome measurement, and selective reporting.[15] Studies that were assessed as having a high risk of bias or scoring low on the quality assessment tools were excluded from the final synthesis.

2.6. Data synthesis and analysis

The data were analyzed using a narrative synthesis approach to identify recurring patterns and categorize findings into thematic areas, such as AI applications in healthcare and biopharma, innovation management frameworks for AI implementation, barriers and enablers of AI integration, and ethical and regulatory considerations. Where quantitative data were available (e.g., on adoption rates or AI effectiveness), descriptive statistics were used. Qualitative themes were identified using thematic analysis.

2.7. Ethical considerations

The ethical use of AI in healthcare requires strong regulatory frameworks to protect patient safety, privacy, and fairness. While regions, such as Europe have established regulations, such as the General Data Protection Regulation and the proposed AI Act, many African countries lack clear oversight, highlighting the need for locally relevant, culturally grounded AI ethics.

Bias in AI remains a major challenge, often stemming from unbalanced data or flawed models. Solutions include technical fixes, such as fairness-aware algorithms and organizational efforts, such as stakeholder involvement and ongoing monitoring.

Explainability is also crucial. Advanced AI models can be opaque, so tools, such as SHAP, LIME, and attention mechanisms help make decisions understandable to clinicians and regulators, building trust in AI systems.

Ultimately, ethical AI requires more than rules – it demands inclusive, transparent innovation management to ensure AI is both effective and equitable in real-world healthcare settings (Figure 1).

3. Results

In this review, key quality assessment criteria were applied across study types to only include high-quality and moderate-quality studies in the synthesis. The quantitative studies were assessed based on the following criteria: (i) Clearly defined inclusion criteria, (ii) detailed description of study setting and literature, (iii) valid and reliable measurement of variables, (iv) identification and appropriate management of confounding factors,

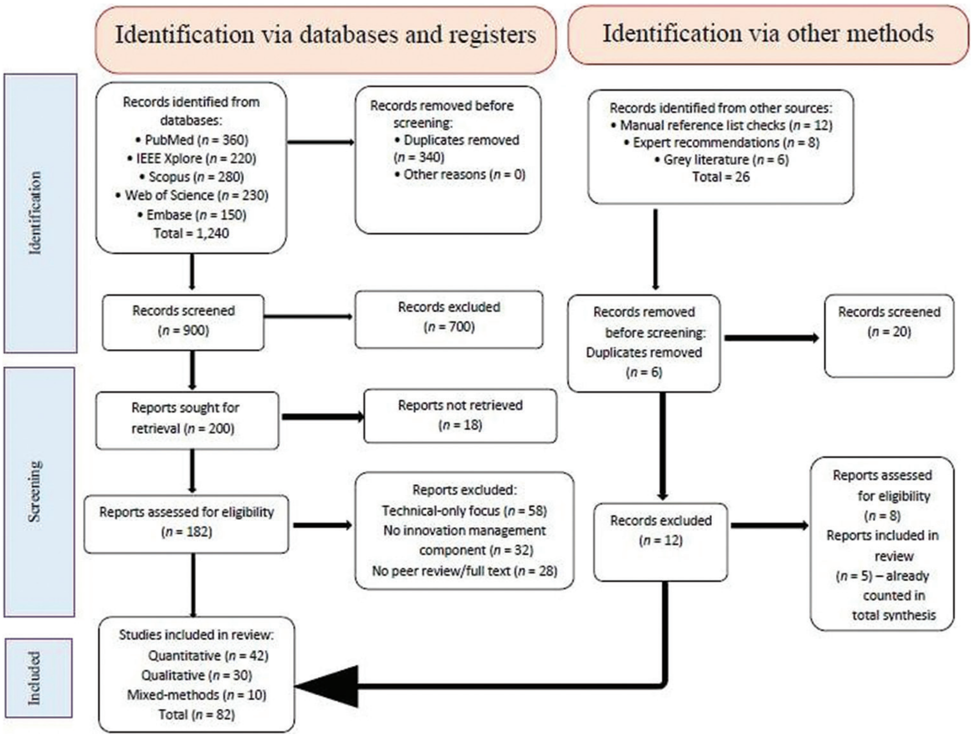

Figure 1. The preferred reporting items for systematic reviews and meta-analyses 2020 flowchart of the study selection process

(v) appropriate statistical analysis, and (vi) transparent reporting and follow-up (where applicable). For qualitative studies, the criteria were as follows: (i) Coherence between research aims and methodological approach, (ii) consistency between research design and data collection methods, (iii) clear representation of participants' perspectives, (iv) ethical considerations and approvals (if stated), (v) data-grounded interpretations, and (vi) researcher reflexivity and positionality are clearly stated.

Each item was assessed as "Yes," "No," "Unclear," or "Not Applicable". Studies with 80% or more "Yes: responses were classified as high quality, those with 60–79% were considered moderate quality, and studies scoring below 60% were deemed low quality and excluded from synthesis.

Subsequently, the findings of this review are categorized into key themes derived from the systematic literature review and case study analysis. These findings offer insights into AI adoption trends, challenges, and strategic approaches to effective innovation management.

3.1. AI adoption trends in healthcare and biopharma

3.1.1. AI-driven diagnostics and drug discovery

Recent advancements in machine learning have significantly enhanced the accuracy of disease detection, particularly in radiology and pathology. AI systems now play a critical role in personalizing treatment plans by analyzing vast datasets to forecast patient responses. In the pharmaceutical sector, AI-driven approaches are streamlining drug discovery, predicting molecular interactions, optimizing clinical trial design, and reducing the time required for new drug development and market entry. In addition, funding models greatly influence access to AI-enabled personalized medicine. For instance, a study from Poland demonstrated that changing the funding model for genetic diagnostics between 2017 and 2019 substantially improved access to personalized oncology services, doubling genetic testing under hospital contracts and more than tripling of separately contracted services. This highlights the importance of adaptive funding strategies to support the scaling of advanced molecular and genetic testing for cancer diagnosis and treatment planning.[16]

3.1.2. Increased investment in AI innovation

The past decade has witnessed a substantial increase in AI-focused research and development, driven by both private investment and public sector support. Governments are incentivizing innovation through targeted funding, while partnerships between academia and industry are fostering the co-creation of AI tools. At the same time, ethical and regulatory frameworks are gradually catching up to support safe and scalable AI integration. For example, an analysis of public payer expenditures on drug programs in Poland between 2015 and 2018 revealed annual reimbursements ranging from approximately USD 635 million to USD 921 million, with oncology-related drug programs accounting for nearly half of this investment. Despite rising costs, such programs remain essential for improving patient access to innovative therapies and addressing diseases with limited treatment options, illustrating the significant financial commitment required to support AI-driven advances in drug discovery and development.[17]

3.2. Challenges in AI innovation management

3.2.1. Ethical and regulatory barriers

Despite its potential, AI adoption in healthcare remains constrained by complex ethical and legal considerations. Patient data privacy is a persistent concern, exacerbated by the lack of unified global regulations. In addition, the opacity of many AI algorithms, particularly in clinical decision-making, raises questions about bias, accountability, and explainability.

3.2.2. Technological and operational challenges

High infrastructure costs, limited digital literacy among healthcare professionals, and interoperability issues all present operational hurdles. AI integration often requires major changes in workflow and system architecture. These challenges can be particularly daunting for under-resourced institutions lacking the technical know-how and manpower for such tasks.

3.3. Strategic approaches to innovation management

3.3.1. Development of AI governance frameworks

Building trust in AI starts with transparent governance. Organizations are increasingly adopting governance models that prioritize ethical standards, patient safety, and regulatory compliance. Explainable AI models are gaining traction; offering clarity in clinical decisions and helping stakeholders make informed judgments. Meanwhile, continuous monitoring systems are being deployed to track AI performance and mitigate risks in real time.

3.3.2. Workforce training and interdisciplinary collaboration

Preparing the healthcare workforce for AI is as critical as AI itself. Institutions are conducting targeted training programs that equip clinicians with the skills needed to work alongside AI systems. Interdisciplinary teams comprising data scientists, healthcare providers, and regulatory experts are emerging as essential units for innovation. These collaborative efforts are proving vital for ensuring AI tools are not only functional but also aligned with clinical realities. These strategic elements are interdependent and form the foundation for successful AI integration. A conceptual framework summarizing these innovation management strategies is presented in Figure 2.

3.4. Case study findings

Real-world applications of AI in healthcare and biopharma demonstrate not only its technological promise but also the strategic maneuvers organizations have adopted to manage innovation effectively. Rather than isolated successes, these cases reflect broader patterns of collaboration, adaptation, and transformation that are reshaping the healthcare landscape.

CSL limited, a global biotechnology leader, offers a compelling example of how AI can be integrated into drug development pipelines to accelerate discovery and reduce research inefficiencies.[18] CSL has strategically invested in machine learning algorithms capable of predicting protein interactions and optimizing compound selection. By leveraging AI during early-stage research, CSL has significantly shortened the timeline for identifying promising drug candidates. More importantly, this integration is supported by a robust internal framework for data governance and cross-functional collaboration, underscoring the importance of structured innovation management in navigating both scientific and regulatory complexities.

Behold.ai, a United Kingdom-based medical technology company, has emerged as a key player in AI-driven diagnostics. Its red dot platform uses deep learning to interpret radiological scans with remarkable speed and accuracy, particularly in detecting lung cancer.[19] Behold.ai distinguishes itself not solely through the robust performance of its AI model but also through its strategic collaboration with the National Health Service to integrate the system into clinical workflows. This collaboration highlights the critical role of stakeholder engagement and regulatory alignment in scaling AI innovation. By ensuring that AI outputs are explainable and compliant with healthcare standards, Behold.ai demonstrates how ethical and operational concerns can be proactively managed within an innovation framework.

Moderna, widely recognized for its rapid COVID-19 vaccine development, exemplifies how AI can revolutionize vaccine research and development. In partnership with OpenAI and other data science entities, Moderna has incorporated large language models and predictive algorithms to refine antigen selection and optimize mRNA sequence designs.[20] This approach has not only accelerated pre-clinical testing but also improved responsiveness to

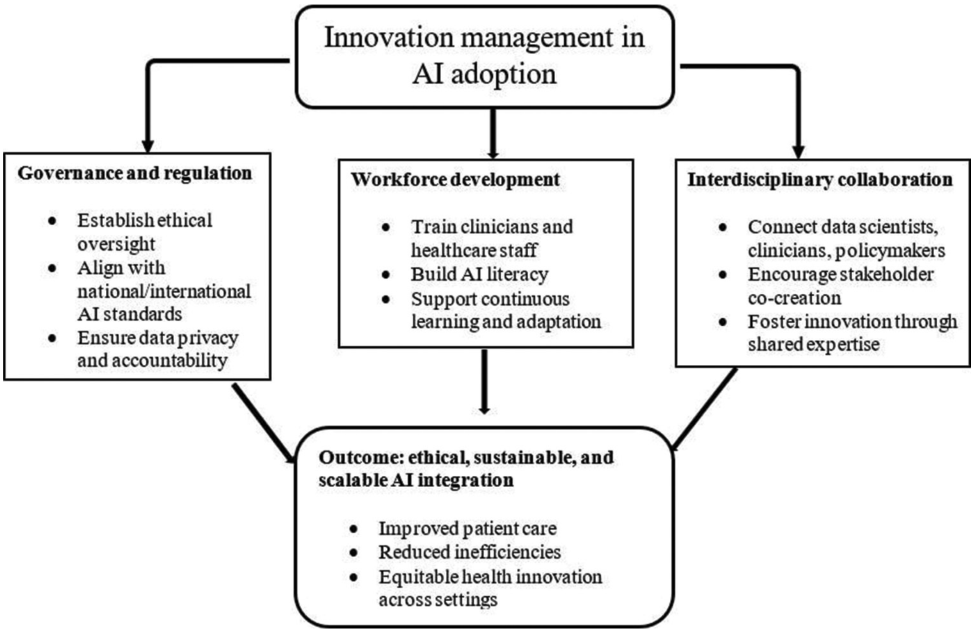

Figure 2. Conceptual framework illustrating key innovation management strategies for artificial intelligence (AI) adoption in healthcare and biopharma

emerging viral variants. Moderna's AI-driven strategies reflect a broader shift toward agile innovation ecosystems where data, modeling, and decision-making are well-integrated. Beyond the laboratory, this has reshaped public health response strategies, reinforcing the role of AI as a cornerstone of future-ready healthcare systems. These case studies illuminate the multidimensional nature of AI integration. They reveal that beyond technical capability, successful innovation depends on how organizations manage partnerships, align with regulations, and build internal capacity for continuous learning and ethical oversight (Table 1).

Table 1. AI applications in healthcare

Organization	AI application	Key outcomes
CSL Limited	AI in drug development	Shortened drug discovery timelines by 40%; improved protein interaction predictions
Behold.ai	AI-driven diagnostics	Lung cancer detection with 94% accuracy; reporting time reduced by 22%
Moderna	AI in vaccine development	Accelerated mRNA development; enabled a rapid response to COVID-19 variants

Abbreviation: AI: Artificial intelligence.

3.4.1. AI applications in radiology

AI has significantly enhanced radiological practices by improving diagnostic accuracy, streamlining workflows, and reducing turnaround times.[21] A previous study demonstrated that AI-assisted workflows reduced average radiology reporting times from 573 to 435 s without compromising diagnostic accuracy, indicating a substantial improvement in efficiency.[22] The United States Food and Drug Administration has approved over 340 AI tools for radiology, primarily for detection tasks, such as identifying brain tumors, strokes, and breast cancer. These tools assist in prioritizing urgent cases and improving diagnostic speed and accuracy.[23] Philips has developed AI-powered magnetic resonance imaging and computed tomography scanners that enhance diagnostic speed and accuracy. These innovations aim to alleviate pressure on health systems and improve patient care.[24] AI models have been developed to predict lung cancer risk from low-dose computed tomography scans, stratifying patients into different risk categories and guiding further diagnostic and treatment decisions.[25]

3.4.2. AI during COVID-19

During the COVID-19 pandemic, AI played a pivotal role in diagnostics, patient monitoring, and public health management. A scoping review identified 66 AI applications used in the clinical response to COVID-19, including tools for analyzing lung images, evaluating symptoms, monitoring vital signs, predicting infections, and aiding in breathing tube placement.[26]

In Singapore, a collaboration between Tan Tock Seng Hospital and research institutes developed "RadiLogic," a deep learning model that interprets chest radiographs quickly, prioritizing abnormal radiographs for early review. The deployment of this solution resulted in a 22% reduction in turnaround times.[27] Researchers from Charles Darwin University and collaborators developed an AI model to diagnose pneumonia, COVID-19, and other lung diseases from lung ultrasound videos with an accuracy of 96.57%. This model also employs explainable AI techniques to assist radiologists in understanding and trusting the model's decisions.[28]

3.4.3. AI in clinical trial design

AI has transformed clinical trial design by enhancing patient recruitment, optimizing protocols, and improving data analysis.[29] Deloitte Insights reported that AI can reduce clinical trial cycle times while improving productivity and outcomes. AI algorithms assist in patient selection, site selection, and monitoring, thereby enhancing the efficiency of clinical trials.[29]

AstraZeneca has utilized AI to optimize trial protocols by analyzing historical trial data and real-world evidence. This approach has enabled the company to design more efficient protocols, resulting in faster trial execution and better resource allocation.[30]

3.4.4. AI applications in LMICs

While most of the literature on AI adoption originates from high-income countries, several LMICs are demonstrating innovative use cases of AI tailored to their specific healthcare challenges. In Nigeria, AI-powered portable ultrasound devices have improved breast cancer detection in rural settings where mammography services are scarce, enabling earlier diagnosis in women under 50.[31] In Brazil, during the COVID-19 pandemic, AI algorithms were deployed in public hospitals to triage patients, using imaging and vital sign data to prioritize Intensive Care Unit admissions and optimize limited critical care resources.[32] Similarly, India has piloted AI-based retinal imaging tools in rural clinics to screen for diabetic retinopathy, achieving a 30% increase in detection rates and reducing referral delays.[33] In the Philippines, AI-enhanced chatbots were integrated into public telemedicine platforms, allowing underserved populations to access remote symptom assessment and pandemic-related health information despite severe physician shortages.[34] These examples highlight how AI, when coupled with local adaptation and supportive innovation management, can bridge critical care gaps in resource-constrained environments.

3.5. Impact of AI on healthcare

AI is redefining innovation management in healthcare and biopharmaceuticals, driving groundbreaking advancements that enhance efficiency, accuracy, and patient outcomes. In 2024, the global AI healthcare market was valued at USD 10.94 billion, with projections estimating it will reach USD 15.48 billion by 2025 and USD 256.53 billion by 2033. This rapid growth is fueled by an annual expansion rate of 41.5% and is largely attributed to breakthroughs in deep learning, natural language processing, and AI-driven diagnostics that are transforming clinical decision-making and treatment strategies. In the United States, AI is accelerating medical innovation, with healthcare providers integrating machine learning models to streamline operations and enhance patient care. AI-powered imaging technologies have improved anomaly detection rates by 85%, significantly enhancing diagnostic precision. Meanwhile, AI-driven hospital management solutions have boosted operational efficiency by 45%, reducing administrative burdens and optimizing resource allocation. The biopharmaceutical industry is also undergoing a transformative shift, as AI-driven drug discovery is shortening research timelines by up to 60%. Advanced AI models facilitate precise molecular simulations, accelerating the identification of viable compounds and reducing the usual time required for drug development. Furthermore, AI-powered predictive analytics in hospitals has enhanced patient monitoring, lowering preventable medical errors by 50% and significantly improving healthcare outcomes. The post-pandemic era has further propelled AI-driven transformation, particularly in telemedicine, which has witnessed a 65% surge in adoption. AI-enhanced virtual consultations now offer real-time decision support, expanding healthcare accessibility and increasing patient engagement. In addition, wearable health devices integrated with AI provide continuous monitoring, with nearly half of users reporting improved health tracking and early intervention benefits. Globally, AI adoption in healthcare continues to accelerate, with over 80% of hospitals in developed regions implementing some form of AI-powered solutions, while emerging markets have experienced a 30% rise in AI-driven healthcare initiatives. Strategic collaborations between AI developers, healthcare institutions, and regulatory bodies are shaping a future where AI-driven healthcare is both scalable and ethically managed, ensuring its sustainable integration into diverse medical ecosystems.[35,36] (Figures 3 and 4).

Overall, based on the synthesis of the literature, several key findings can be highlighted. First, AI-driven diagnostics and drug discovery are experiencing rapid advancements. Moreover, ethical and regulatory concerns require structured governance mechanisms, while workforce training and interdisciplinary collaboration play a crucial role in AI adoption. In addition, case studies demonstrate the measurable benefits of AI in improving healthcare efficiency and drug development. These

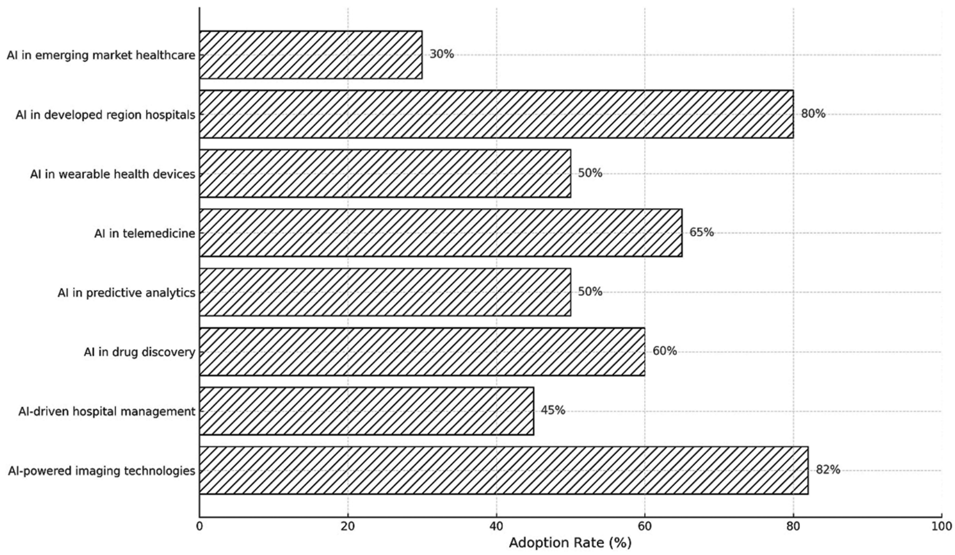

Figure 3. Artificial intelligence (AI) adoption trends in different healthcare sectors (2023 estimates). This figure illustrates the extent to which AI technologies have been integrated across various sectors of healthcare, including wearable health devices, telemedicine, predictive analytics, drug discovery, hospital management, and imaging technologies. Adoption trends refer to the percentage of healthcare institutions or organizations implementing AI-based tools or systems within their operational workflows. Data sourced from Global Growth Insights[35] and Fishchuk.[36]

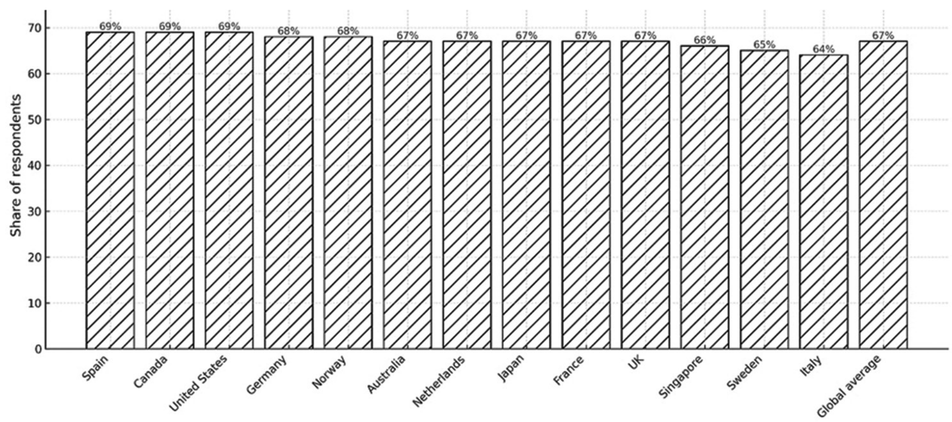

Figure 4. Consumer perceptions of artificial intelligence (AI) in healthcare across countries (Adapted from Statista, 2023). This chart displays the percentage of surveyed individuals in selected countries who consider AI-generated medical opinions helpful. Perception rates refer to public trust and perceived usefulness of AI recommendations in clinical or diagnostic settings. Data derived from a global consumer sentiment survey on AI applications in healthcare, conducted by Statista in 2023.[37]

findings emphasize the necessity of structured innovation management strategies to ensure the ethical, efficient, and impactful integration of AI in healthcare and biopharma (Figure 5).

4. Discussion

This systematic review emphasizes the transformative potential of AI in reshaping both healthcare delivery and pharmaceutical innovation. While AI has proven its ability to enhance diagnostics, personalize treatments, and accelerate drug discovery, its full potential depends on effective innovation management. This discussion synthesizes key implications, highlights strategic frameworks, and outlines challenges and opportunities for sustainable AI integration.

4.1. Implications of AI in healthcare and biopharma

AI applications have markedly improved diagnostic accuracy, early disease detection, and personalized care. For example, Topol[1] and Obermeyer and Emanuel[2] emphasized AI's role in reducing clinical errors and administrative burdens. In biopharma, AI-driven models

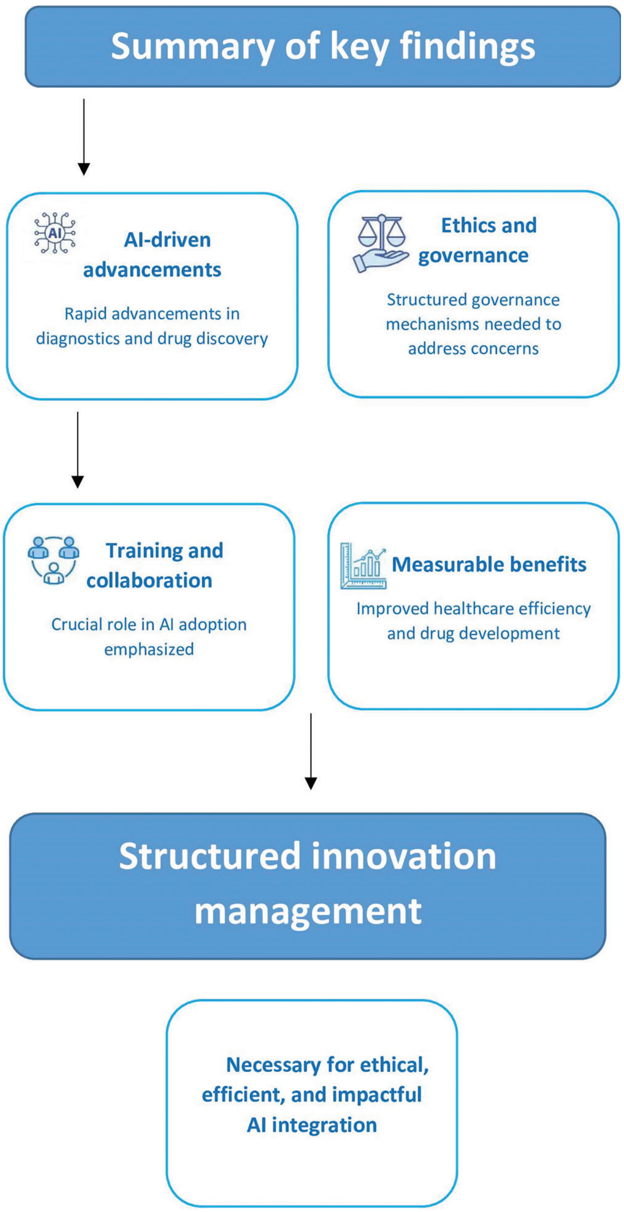

Figure 5. An overview of key findings on AI adoption in healthcare and biopharma. The diagram illustrates four central themes identified in the review: Rapid advancements in AI-driven diagnostics and drug discovery, the need for ethical and regulatory governance, the importance of workforce training and interdisciplinary collaboration, and the measurable benefits of AI integration. Collectively, these elements highlight the critical role of structured innovation management in guiding responsible and effective AI implementation across the healthcare and biopharmaceutical sectors.
Abbreviation: AI: Artificial intelligence.

expedited biomarker discovery and molecular design,[8] as illustrated by Moderna's use of AI in mRNA vaccine development during the COVID-19 pandemic.[20]

Such examples affirm that innovation management, through alignment of governance, training, and collaboration, enables AI to move from experimental phases to impactful clinical and industrial use.

4.2. Addressing ethical and regulatory challenges

Despite these benefits, ethical concerns and regulatory inconsistencies remain significant hurdles. The European Union's General Data Protection Regulation and proposed AI Act offer a model for risk-based AI governance.[38] However, many LMICs lack dedicated frameworks, resulting in fragmented oversight.[39] In addition, dominant ethical models shaped by the Global North may not adequately address localized priorities, prompting calls for "decolonized AI ethics" tailored to specific cultural and healthcare systems.[40]

To ensure equitable AI deployment, innovation strategies must include not only compliance mechanisms but also context-sensitive ethical guidance.

4.3. Overcoming technological and operational barriers

Infrastructure limitations, poor data access, and low digital literacy hamper AI adoption in many LMICs.[41] AI deployment in LMICs must be adapted to local realities, such as infrastructure gaps, limited internet access, and weak regulatory systems.[31,32] Unlike high-income countries, LMICs often face challenges with fragmented data and digital readiness. Real-world examples from Nigeria, Brazil, India, and the Philippines highlight that successful implementation depends on contextual adaptation, including mobile-based diagnostics and public–private partnerships.[33,34] To prevent widening health disparities, AI innovation strategies should include capacity-building, locally driven governance models, and culturally responsive ethical frameworks that reflect indigenous values and healthcare goals.[42] Countries, such as Thailand and Vietnam offer emerging models of regulatory adaptation.[43] Innovation management frameworks that incorporate stakeholder engagement, iterative feedback, and clinician involvement are key to overcoming such barriers.[38]

Institutions, such as Kaiser Permanente and initiatives, such as the United States Cancer Moonshot demonstrate how innovation management can enhance implementation fidelity and real-world impact, as long as over-reliance on unvalidated AI models is avoided.[44,45]

4.4. Strategies for effective innovation management

This review identified five core strategies essential to managing AI adoption:

(i) Governance frameworks to enable ethical oversight, accountability, and transparency[12,38]
(ii) Workforce training to build digital literacy among healthcare providers.[3]

(iii) Interdisciplinary collaboration to integrate perspectives from clinicians, data scientists, and regulators.[6]
(iv) Explainable and ethical AI to encourage adoption of interpretable models.[44,46]
(v) Regulatory alignment to advocate for international standards and harmonized policies.[11,43]

These strategies create an enabling ecosystem that supports both technological innovation and ethical integration.

4.5. Future directions and research opportunities

Technologies, such as blockchain, Internet of Medical Things, and federated learning are expanding the innovation landscape. Blockchain ensures data traceability in clinical trials, the Internet of Medical Things facilitates continuous patient monitoring, and federated learning enables secure, collaborative model training across institutions.

As the market for AI in healthcare grows, managing these innovations effectively – through agile, adaptive frameworks – will be critical to realizing their full potential.

4.6. Limitations of the study

This review is subject to certain limitations. The included studies varied widely in design, scope, and outcome measures, thereby reducing comparability. Moreover, articles not in English or not peer-reviewed were excluded. Some AI models reviewed lacked long-term performance data or robust validation. Hence, future work should explore meta-analytical approaches and consider grey literature and non-English sources for broader inclusivity.

4.7. Future directions

4.7.1. Blockchain in healthcare

Blockchain technology offers a decentralized and immutable ledger system, ensuring secure and transparent handling of sensitive health data. Key applications include:
(i) Electronic health records: Blockchain facilitates secure sharing and management of electronic health records, enhancing interoperability among healthcare providers.
(ii) Clinical trials: It ensures data integrity and transparency in clinical trial processes, reducing the risk of data manipulation.[47]
(iii) Supply chain management: Blockchain enhances the traceability of pharmaceuticals, combating counterfeit drugs.

4.7.2. Internet of medical things

The Internet of Medical Things refers to the network of interconnected medical devices and applications that collect and transmit health data. Its applications include:[48]
(i) Remote patient monitoring: Wearable devices track vital signs, enabling continuous monitoring and early detection of health issues.
(ii) Chronic disease management: Internet of Medical Things devices assist in managing conditions, such as diabetes and hypertension by providing real-time data to healthcare providers.
(iii) Emergency response: Connected devices can alert medical personnel during emergencies, improving response times.

4.7.3. Federated learning in healthcare

Federated learning enables multiple institutions to collaboratively train machine learning models without sharing raw data, preserving patient privacy. Applications include:[49,50]
(i) Collaborative research: Hospitals can jointly develop predictive models for disease diagnosis without compromising data security.
(ii) Personalized medicine: Federated learning supports the creation of individualized treatment plans by analyzing diverse datasets.
(iii) Pandemic response: It facilitates the rapid development of models to track and predict disease outbreaks across regions.

5. Conclusion

AI holds immense promise for reshaping healthcare and biopharma. However, this promise can only be fulfilled through deliberate, well-managed innovation that bridges the gap between cutting-edge algorithms and real-world patient outcomes. Policymakers, healthcare leaders, and technologists must work collaboratively to ensure that AI is not only advanced but also accessible, ethical, and transformative in the truest sense. For this to occur equitably innovation strategies must actively account for the unique challenges and opportunities present in LMICs. Investment in digital infrastructure, regional regulatory capacity, and context-aware governance frameworks is essential to prevent the exacerbation of global health disparities. The next wave of AI advancement must be both inclusive and adaptive, anchored in principles that prioritize equity, sustainability, and human-centered care across all healthcare systems.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: All authors
Visualization: All authors
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Writing – review & editing: All authors

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

Not applicable.

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