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Artificial Intelligence Techniques in Blockchain-Integrated Healthcare and Financial Systems: A Systematic Review and Future Research Agenda

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Research Article

Keywords: Blockchain, Artificial Intelligence, Healthcare systems, Financial systems, Data security, Fraud detection, Digital banking, Interoperability, Explainable AI (XAI)

Posted Date: February 24th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-8844280/v1

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Additional Declarations: No competing interests reported.

Abstract

Blockchain and artificial intelligence (AI) are two innovative technologies that are impacting modern infrastructures with resilience, intelligence, and transparency. Blockchain offers immutability, decentralization, and trust, while AI facilitates decision assistance, anomaly detection, and predictive analytics. Scholarly interest in their convergence has grown for mission-critical domains including healthcare and finance. This narrative review evaluates the possibilities, difficulties, and future prospects of combining blockchain technology with artificial intelligence by compiling 53 research papers published between 2018 and 2025. This evaluation categorizes AI methods used in blockchain-integrated systems, including explainable AI models, federated learning, deep learning (CNN, RNN, transformers), and supervised learning (SVM, RF). Using PRISMA-inspired narrative synthesis principles, this work systematically synthesizes 53 peer-reviewed papers to ensure methodological openness and analytical rigor. The healthcare sector makes extensive use of telemedicine, secure medical data transmission, diagnostic support, and drug supply chain traceability. Fraud detection, digital banking innovation, and the creation of central bank digital currencies are all made possible by the integration of blockchain and artificial intelligence in financial institutions. The review creates a taxonomy of AI techniques and assesses their relative effectiveness and drawbacks in the financial and healthcare sectors. The analysis reveals persistent issues like scalability, interoperability, privacy, and regulatory ambiguity in addition to ethical considerations concerning explainability and fairness. We point out shortcomings in scalable federated blockchain–AI architectures, XAI frameworks, and benchmarking datasets.

This paper offers a thorough synthesis that gives scholars and business experts a comprehensive understanding of how blockchain and artificial intelligence will affect future infrastructures. The study offers a comparative assessment of methodological methods, identifies unresolved problems with explainable models and federated architectures, and suggests a methodical research plan in addition to mapping applications of blockchain–AI convergence. Unlike other evaluations that concentrated on a single domain, this analysis reveals shared design principles and governance implications by presenting a cross-sector synthesis of healthcare and finance systems.

1. Introduction

Digital technology' quick development has changed how societies handle value, trust, and information. Blockchain and artificial intelligence (AI) are two of these advancements that stand out as game-changing technologies with unique yet complimentary qualities. While AI offers predictive analytics, pattern recognition, and intelligent decision-making, blockchain guarantees transparency, immutability, and decentralized trust [1]. Organizations are seeing the value of comprehending these technologies' combined, synergistic potential as they develop [2]. Their combination, sometimes known as technology synergy, creates new opportunities for developing data-driven, secure, and sector-neutral infrastructures. The Investment–Culture Dual-Core Driven Type and Management–Attention Synergy Type are two organizational synergy models that further illustrate how these integrations appear at the structural and operational levels[3].

Healthcare and finance systems are especially attractive fields for this confluence. AI approaches already play a transformational role in general medicine[4], enabling individualized treatment, diagnostic support, and predictive illness modeling. Large amounts of sensitive data subject to stringent privacy and security laws must be accessible for these applications. By guaranteeing auditability, secure exchange, and verifiable data provenance, blockchain can meet these demands. AI speeds up risk assessment and fraud detection in the banking industry, while blockchain improves transaction integrity and transparency. [5]. Blockchain and AI work together to strengthen intelligence, security, and trust in mission-critical systems.

Using a narrative systematic synthesis, this paper investigates the advantages, difficulties, and ramifications of blockchain–AI integration in the healthcare and financial industries. Applications are mapped, persistent challenges are identified, and methodological maturity across domains is examined. The study offers a comprehensive understanding of cross-sector possibilities and conflicts by combining knowledge from both disciplines.

The finding that previous research frequently treats healthcare and finance independently, despite significant structural parallels in their data requirements, risk profiles, and governance demands, is a major driving force behind this analysis. Deep learning

developments have improved AI's capacity to interpret complicated patterns and medical imaging [6].However, in settings that demand verified, tamper-proof data exchange, blockchain strengthens trust mechanisms. There is no common analytical paradigm that assesses integration depth, interoperability, explainability, and scalability across both sectors; instead, previous assessments have mostly offered domain-specific or descriptive overviews.[7].

This paper specifically examines how AI methods—such as supervised learning, deep learning, federated learning, anomaly detection, and explainable AI—interact with blockchain infrastructures in financial and healthcare systems in order to address these issues. It creates a taxonomy of AI models, analyzes their capabilities and constraints, and determines whether blockchain-AI solutions are ready for practical application. Shared governance concepts, trust mechanisms, and architectural requirements that cut across different industries are made clear by this cross-sector viewpoint.

Accordingly, this review pursues three objectives:
(1) In order to provide an overview of the current state of blockchain and AI convergence in financial and healthcare systems,
(2) To assess current frameworks critically, emphasizing their governance, methodological, and technical flaws; and

(3) To provide a future research agenda with integrated governance, scalable architectures, explainability, and interoperability as top priorities.

2. Literature Review

2.0 Taxonomy of AI Techniques in Blockchain-Enabled Systems

There are six main categories into which artificial intelligence methods employed in blockchain-integrated financial and healthcare systems can be divided (Figure 2). Variations in learning paradigms, computational needs, interpretability, and appropriateness for safe, distributed settings are all reflected in this classification.

(A) Supervised Machine Learning

Comprises XGBoost, SVM, Random Forest, Decision Trees, and Logistic Regression.
used mostly for risk rating, structured clinical data classification, and fraud detection.

Strengths: high precision and clear decision-making boundaries.

Limitations: limited scalability for unstructured data; needs annotated datasets.

(B) Deep Learning

CNNs, RNNs, LSTMs, and developing models based on Transformers. Prominent in blockchain log analysis, physiological signal modeling, and medical imaging.

Strengths: capable of handling multimodal data; powerful representational power.

Limitations: Excessive computational expense and poor interpretability.

(C) Unsupervised Learning

Clustering methods, Isolation Forest, and autoencoders.

The most common uses are for identifying irregularities in financial transactions and questionable patterns of healthcare access.

Strengths: Excellent for detecting fraud; no labels are required.

Limitations: Hyperparameters and data quality determine performance.

(D) Reinforcement Learning (RL)

Used to maximize resource distribution, adaptive smart contracts, and blockchain consensus.
Strengths: facilitates decentralized decision-making and is dynamically adaptable.
Limitations: Seldom verified on actual blockchain networks.

(E) Federated Learning (FL)

Permits training between institutions without the need for centralized data sharing.
essential for healthcare AI systems that protect patient privacy.

Strengths: compatible with blockchain audits; improves privacy and compliance.
Limitations: Include diverse client data and connection overhead.

(F) Explainable AI (XAI)

Grad-CAM, LIME, SHAP, and counterfactual justifications. vital in high-risk fields where interpretability is necessary.

Strengths: Openness and compliance with regulations.

Limitations: Restricted scalability; explanations might not hold up.

Table A: AI Taxonomy and Blockchain Integration Roles

AI Category	Example Models	Strength	Limitation	Typical Blockchain Use
Supervised ML	RF, SVM, XGBoost	High accuracy	Needs labeled data	Fraud detection, risk scoring
Deep Learning	CNN, RNN, Transformers	Handles complex patterns	High compute	Imaging, blockchain log analytics
Unsupervised	Autoencoder, Isolation Forest	Detects anomalies	Sensitive to parameters	AML detection, unusual access
Reinforcement Learning	DQN, PPO	Adaptive optimization	Sparse validation	Consensus tuning
Federated Learning	FedAvg, FedProx	Privacy-preserving	High communication cost	Hospital networks
Explainable AI	SHAP, LIME	Transparency	Limited generality	Auditing AI outcomes

2.1 Blockchain in Healthcare and Finance

Blockchain has shown promise in the fields of clinical trial openness, patient data sharing, and electronic health record (EHR) management. The digital version of a patient's medical record that contains extremely private and sensitive information about their history, diagnosis, and course of treatment is called an electronic health record (EHR) [1].Applications of AI in healthcare include improving diagnostic precision, customizing patient treatment, and expediting the drug discovery process [6]. Peers can work together to create a decentralized network using the blockchain distributed ledger [7]. By guaranteeing drug tracking and reducing the possibility of counterfeiting, it improves supply chain integrity. Around the world, technology has completely changed the banking sector [8]. Examining the contrast between traditional and decentralized finance, it clarifies how governance, accessibility, security, and regulatory frameworks differ [5]. These uses demonstrate how blockchain may promote efficiency and trust in fields where data is sensitive. Blockchain has the ability to transform heath care systems into a horizontal technology that has revolutionized other industries [6].

Blockchain and AI were specifically coupled at the data or system level in 18 healthcare-focused research and 22 finance-focused studies among the included studies. Less than 10 studies expanded the use of blockchain-integrated systems beyond pilot settings, while just 13 studies applied deep learning models at scale.

Important Takeaway: Although recent research shows that blockchain can improve data integrity and traceability, interoperability issues between financial institutions and healthcare providers are still mostly unresolved. Similar to this, the majority of AI applications are still in the experimental stage and have not yet been widely used in healthcare or financial settings. This disparity emphasizes the necessity of integrated frameworks that use AI's analytical powers in conjunction with blockchain's security to provide scalable and reliable cross-domain solutions.

Critical Insight: Blockchain enhances trust and data integrity, but its integration with AI in healthcare and finance is still disjointed. There is little cross-domain compatibility, and pilot studies frequently use small datasets. A comparative study of architectures shows that whereas financial systems place more emphasis on transaction speed and transparency, healthcare-focused systems place more emphasis on privacy-preserving data exchange. This disparity implies that healthcare interoperability models should benefit from fintech lessons and vice versa.

2.2 Artificial Intelligence Applications

Medical imaging analysis, predictive illness modeling, diagnostic assistance, and individualized treatment plans are just a few of the ways AI is revolutionizing healthcare. In the fields of healthcare and biological sciences, machine learning models hold great promise[7]. The clinical care route should be impacted by AI-assisted medical devices that are created using multicenter heterogeneous datasets[8]. Over the past ten years, artificial intelligence (AI) has significantly increased in the healthcare industry. With the potential to transform clinical decision-making and improve operational efficiencies, artificial intelligence (AI) is being used more and more in a variety of industries, including healthcare [9]. AI applications have specifically been used to extract information from clinical data and support medical professionals in a variety of clinical tasks, including risk analysis, disease diagnosis, triage or screening, and surgical procedures [10]. AI is used in finance to enable fraud detection, algorithmic trading, credit scoring, and analytics of consumer behavior. AI is constrained by worries about explainability, model bias, and data privacy, despite its potential. Blockchain, which can provide verifiable, auditable data pipelines for AI training and deployment, naturally complements this. From conventional machine learning to deep neural models, artificial intelligence (AI) includes computational methods that can learn, reason, and make decisions. Its acceptance varies by maturity, legislation, and ethical governance in the healthcare and financial sectors [10]. On the other hand, blockchain offers the whole provenance or history of data. A blockchain digital ledger can be used to hold vaccination statuses, patient data, discharge summaries, and sample test results [11].

Comparatively speaking, Healthcare AI encounters ethical and data governance challenges, while financial AI applications are typically more developed and controlled. There is a cross-domain gap in the few research that look at the transferability of AI governance systems from healthcare to finance.

CNNs were employed in eleven healthcare applications, RNN/LSTM in six, Random Forest in nine financial studies, and Autoencoders or Isolation Forest in seven anomaly detection implementations of the 53 reviewed papers. There is a substantial methodological gap as only four studies used explainable AI techniques and only five used federated learning.

2.3 Synergy Between Blockchain and AI

AI and blockchain technology combine to take use of complementary advantages. In recent years, there has been a lot of interest in the integration of blockchain technology with artificial intelligence (AI), particularly because this integration can enhance the security, productivity, and efficiency of applications in business environments that are marked by volatility, uncertainty, complexity, and ambiguity[13]. Blockchain improves the dependability of AI outputs by guaranteeing the provenance and integrity of datasets. By facilitating the intelligent automation of smart contracts, anomaly detection in decentralized ledgers, and predictive maintenance of distributed networks, artificial intelligence (AI) in turn enhances blockchain ecosystems. Blockchain technology and artificial intelligence (AI) are two seemingly unrelated technologies that could perhaps compliment one another. Unquestionably, the adoption of paradigms based on blockchain technology and artificial intelligence (AI) is accelerating[14].As technology develops, it is critical for corporate leadership to understand the revolutionary and synergistic possibilities of blockchain and AI. In the dynamic global marketplace, this mentality will assist companies in preserving a competitive edge[12].When combined, they make it possible to build trustworthy, intelligent, and decentralized infrastructures that are appropriate for high-stakes environments.

Analytical Synthesis: Rather than treating blockchain and AI as interdependent systems, the majority of implementations view them as complementary tools. Unified design patterns that specify how blockchain's trust mechanisms can directly improve the auditability of AI models or how AI-driven optimization can dynamically manage blockchain consensus processes are lacking in the literature.

2.4 Existing Reviews and Research Gap

Previous assessments have mostly looked at AI in financial systems or blockchain in healthcare separately. In certain fields like supply chains, logistics, or smart cities, others have investigated the integration of blockchain technology with artificial intelligence. Cross-domain studies that evaluate healthcare and finance together are still rare, nevertheless. Furthermore, gaps still exist in areas like privacy-preserving federated frameworks, explainable AI (XAI) for blockchain-integrated models, and policy-oriented studies addressing interoperability and regulation. By combining healthcare and financial viewpoints in a comprehensive synthesis, this review aims to close these gaps.

Seldom are methodological robustness and comparative maturity across industries evaluated in existing assessments. Furthermore, no longitudinal research has been done to demonstrate how the link between blockchain and AI has changed over time. This disparity emphasizes the necessity of a methodical analytical assessment that goes beyond descriptive synthesis in order to assess ethical preparedness, scalability, and impact.

3. Methodology

This work uses a narrative systematic review approach informed by PRISMA guidelines to guarantee conceptual integration, transparency, and repeatability. PRISMA 2020 flow chart for fresh systematic reviews that just included registration and database searches[16].The review concentrates on combining interdisciplinary findings pertinent to blockchain–AI convergence across sectors rather than doing a thorough methodological screening. Major scholarly databases such as Google Scholar, Web of Science, SpringerLink, Wiley Online Library, and Scopus were used in a structured search. To collect a range of viewpoints on blockchain and AI applications in healthcare and financial systems, the search method combined specified keywords with Boolean operators. Among the primary keyword combinations were: Blockchain AND Artificial Intelligence AND Healthcare; Blockchain AND AI AND Financial Systems; Blockchain AND AI integration AND Healthcare AND Finance; Blockchain AND AI AND Medical data security; Blockchain AND AI AND Payments OR Banking; Blockchain AND Machine Learning AND Healthcare applications; *and* Blockchain AND Artificial Intelligence AND Fraud Detection.

Due to the increased interest in the intersection of blockchain and artificial intelligence, the search was restricted to peer-reviewed publications released between 2018 and 2025.

The following were the requirements for inclusion:

1. Clearly stating how blockchain and AI are integrated,
2. Use in financial and/or healthcare systems, and
3. Pay attention to prospects, difficulties, or potential paths.

Excluded were studies that only addressed blockchain or AI without any integration. 53 studies were examined from the library and additional searches that were gathered. Contributions were divided into three categories: benefits, use case, and domain. Findings from healthcare, finance, and cross-domain potential were compiled after theme coding, with consideration given to obstacles and unmet research needs.

This study adopted a PRISMA-inspired methodology tailored for narrative reviews in order to improve methodological transparency and reproducibility. The steps of identification, screening, eligibility, and inclusion were recorded using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. Using the chosen keyword combinations, 312 documents were first obtained from databases including Google Scholar, Scopus, SpringerLink, Wiley Online Library, and Web of Science.Titles and abstracts were used to filter 248 unique items after duplicates (n = 64) were eliminated. 132 of these were disqualified for failing to address the combination of blockchain and AI. Out of the 116 papers that underwent full-text

evaluations, 63 did not satisfy the requirements for inclusion (for instance, they concentrated on unrelated fields or only covered one technology). Ultimately, the synthesis comprised 53 peer-reviewed articles. Using a PRISMA-style flow diagram, Fig. 1 provides an overview of the research selection procedure.

Criteria	Inclusion	Exclusion
Integration Focus	Blockchain + AI combined studies	Only blockchain or only AI
Domain	Healthcare, Finance, or both	Other unrelated domains
Publication Type	Peer-reviewed journal/conference papers	Preprints, blogs, non-academic works
Time Range	2018–2025	Before 2018

The chosen papers were coded using thematic synthesis with an emphasis on the following to improve analytical rigor:

1. Application domains,
2. Integration depth (data, model, or system level), and
3. Reported outcomes or challenges.

In order to find overlapping design motifs, a cross-tabulation of studies on healthcare and finance was done. To illustrate the evolution of research, quantitative variables including the distribution of domain focus and the publication trend (2018–2025) were also noted.

4. Opportunities in Healthcare

4.1 Secure Medical Data Management

The necessity for safe data sharing, interoperability, and intelligent diagnosis has led to the most developed blockchain-AI integration experimentation in the healthcare industry. Biomedical image categorization uses artificial intelligence algorithms for diagnostic sciences[17]. Managing sensitive patient data across disparate platforms is a recurring concern for the healthcare industry. Secure electronic health records (EHRs) that are impenetrable are made possible by blockchain's immutability and decentralized access. Blockchain rallies in healthcare: Putting patients first is a white paper released by the Institute for Business Value at IBM [18]. Such records serve as a basis for disease modeling, personalized treatment, and predictive diagnostics when paired with AI-driven analytics. Blockchain, for instance, guarantees the provenance and integrity of medical data, and artificial intelligence (AI) derives useful insights that improve utility and trust. The suggested evaluation looks at how blockchain technology and artificial intelligence (AI) can be combined to solve current issues with healthcare data security and privacy[13].

4.2 Medical Diagnostics and Imaging

AI has shown impressive performance in picture recognition tasks in radiology and pathology applications. Several aspects of data analysis should be taken into account in radiology, and some of the most recent deep learning techniques are shown [19]. Algorithm performance has been demonstrated to be on par with that of an expert pathologist evaluating whole-slide images (WSIs) without time limits, and artificial intelligence is routinely better than humans at doing repetitive, intricate jobs quickly and accurately[20].By combining disparate data sources—such as pictures, signals, structured documents, and clinical narratives—into a single analytical framework, multimodal artificial intelligence (MAI) overcomes these drawbacks. Furthermore, we outline a novel strategy known as "explainable AI" and explain how AI may support pediatric radiologists [21].These systems increase clinical interpretability, prediction accuracy, and diagnostic robustness by utilizing the complimentary qualities of each modality[16]. However, access to large, varied datasets is necessary for training these models, a process that is hampered by privacy regulations. Federated learning, in which data stays local but models learn collectively, can be made possible by blockchain-enabled data-sharing frameworks that allow safe and private interactions between hospitals. Thus, the synergy promotes early disease identification, lowers biases, and improves diagnostic accuracy.

4.3 Drug Supply Chain Management

Drug counterfeiting continues to be a global problem, putting people at risk and costing billions of dollars every year. Applications of AI in healthcare include improving diagnostic precision, customizing patient treatment, and expediting the drug discovery process[17]. According to the U.S. Trade Representative's annual report on "infamous markets," almost all of the 35,000 internet pharmacies in the globe are operating illegally, and customers who use them face the risk of receiving unsafe or inefficient medications. Additionally, 19 countries were singled out in the report due to worries about pirated or counterfeit goods [18]. Blockchain makes it possible to trace pharmaceutical supply chains, guaranteeing that all stages—from manufacturing to delivery—are transparently documented. By predicting demand, streamlining logistics, and spotting irregularities in distribution patterns, AI enhances this. The potential for blockchain technology and artificial intelligence (AI) to work together to change healthcare is examined in this perspective paper. An outline of blockchain's applications in clinical trials, pharmaceutical supply chains, security, healthcare data management, and health insurance is given in the outset. The influence of AI on healthcare is then discussed, and the advantages of combined AI–blockchain platforms are next examined[19]. AI and blockchain work together to improve pharmaceutical ecosystems' efficiency and validity.

4.4 Telemedicine and Remote Care

The COVID-19 pandemic has hastened the growth of telemedicine, which has led to a greater dependence on digital platforms for the provision of healthcare.Additionally, they can assist in managing limited healthcare resources to reduce the enormous hospital COVID-19 patient burden[20]. Blockchain guarantees safe patient and provider identity management and verification, while AI facilitates individualized treatment suggestions and ongoing remote monitoring via wearable technology. AI and wearable technology promise promising outcomes in CDM. In the healthcare sector, wearable technology refers to portable medical electronics [25]. Integration lowers accessibility barriers in underprivileged areas and increases confidence in remote healthcare services.

In summary, the papers under consideration show that although AI propels interpretative intelligence, blockchain improves data provenance. The majority of research are only conceptual or pilot in scope, and integration maturity is still low. According to comparative analysis, blockchain adoption is hampered by interoperability and scalability issues, even though AI enhances diagnosis and predictive care. Future healthcare systems ought to investigate tiered designs in which AI dynamically controls privacy and trust mechanisms while blockchain maintains data integrity.

Seven of the assessed papers focused on telemedicine or remote care systems that combine blockchain-secured trade layers with AI-driven analytics. Only two of the suggested systems have reported pilot deployments, while the majority are still conceptual.

5. Opportunities in Financial Systems

5.1 Fraud Detection and Risk Management

Transparency, fraud detection, and real-time risk assessment are the major goals of blockchain and AI integration in the financial sector, which reflects industry interests in automation and trust. For the purpose of identifying unusual transaction behavior, the systems usually combine unsupervised algorithms like isolation forests and autoencoders with supervised learning algorithms like random forests and decision trees[26].AI is transforming financial services through algorithmic trading optimization, risk management, and fraud detection. In addition to automated trading, investments, insurance, and risk management, financial technology, or FinTech, represents a new frontier in finance by utilizing technology to innovate and address persistent market issues[7].AI uses cutting-edge machine learning algorithms to identify trends and abnormalities in real time, reducing false positives and expediting fraud detection. With AI-powered fraud detection systems that examine enormous databases and identify illegal activity with unmatched accuracy, financial institutions can now defend against sophisticated cyberattacks [21]. Insider trading, transaction fraud, and cyberattacks pose a growing threat to financial institutions. Blockchain offers immutable records that improve the accuracy of such analytics, while artificial intelligence (AI) is excellent at finding unusual patterns in large datasets. Institutions may enhance market surveillance, manage risks, and proactively detect fraud by combining blockchain records with AI anomaly detection algorithms.

Twelve of the fifty-three research dealt with financial abnormality or fraud detection. Only three used blockchain-enhanced reinforcement learning environments, whereas the bulk employed Random Forest, Isolation Forest, or Autoencoders.

5.2 Digital Banking and Real-Time Payments

Globally integrated, digital banking is defined by the convergence of technology and banking. The term "digital banking" refers to the full digitization of banking operations that employ a model distinct from conventional methods[22]. Secure, effective, and transparent payment infrastructures are necessary as a result of the global migration to digital banking. Both artificial intelligence and big data have long been recognized as essential components of efficient administration in the majority of various commercial domains [23]. While AI examines consumer behavior to tailor services and forecast financial demands, blockchain facilitates decentralized payment rails, peer-to-peer settlements, and cryptocurrencies. Real-time payments with reduced expenses and increased confidence are promoted by their integration.

5.3 Anti-Money Laundering (AML) and Compliance

The commercial market that surrounds the fight against money laundering is referred to as the "compliance industry." Our goal is to map this sector and investigate its role in the fight against money laundering [24]. Accurately identifying suspicious activity is necessary for AML compliance. One of the biggest problems facing the world's financial system is money laundering, which is the illicit practice of disguising large sums of money obtained through unlawful activities like drug trafficking or fraud as coming from a legitimate source [30]. Blockchain offers auditable trails that cannot be changed after the fact, while AI-driven algorithms can examine enormous transaction networks to identify irregularities. This collaboration improves transparency, fortifies regulatory compliance, and cultivates confidence between regulators and institutions.

5.4 Central Bank Digital Currency (CBDC) and Cryptocurrency

In order to improve financial inclusion and lower transaction costs, governments create digital currencies known as Central Bank Digital Currencies (CBDCs), which have the same value as a nation's fiat currency [25]. Growing awareness of blockchain's significance in digital finance is reflected in the rise of cryptocurrencies and state-led CBDC efforts. AI is capable of tracking market dynamics, forecasting demand for CBDCs, and simulating monetary policy. Central banks throughout the world are actively researching CBDC due to the rise of private money, such as cryptocurrencies and stablecoins, and the expanding use of digital payments to slow the spread of pandemics [26].AI and blockchain work together to support emerging currency ecosystems' acceptance, governance, and stability.

In assumption, Because of data standards and regulatory incentives, the financial industry is more prepared to integrate blockchain technology with artificial intelligence. However, healthcare places a greater premium on ethics and privacy than on efficiency and profit. According to a comparative synthesis, healthcare's privacy-preserving frameworks could direct responsible financial AI governance, while financial governance models could influence compliance processes for healthcare data systems.

5.5 Comparative Evaluation of AI Techniques Across Domains

Healthcare Domain

For imaging tasks, CNNs routinely perform better than classical ML; 11 research have achieved AUC values ranging from 0.85 to 0.97. Despite their restricted dataset diversity, RNNs and LSTMs are mainly utilized for physiological time-series modeling. Five healthcare studies use federated learning, which allows for privacy-preserving model training across institutions. However, given extremely heterogeneous data, performance suffers.

Financial Domain

In nine research, unsupervised anomaly detection—especially Isolation Forest and Autoencoders—dominates. With the use of structured tabular datasets, Random Forest models consistently perform well for credit scoring and fraud risk categorization. Transformer-based models are becoming more popular in transaction forecasting, although their validation is still lacking.

Cross-Domain Insights

Healthcare AI places more emphasis on privacy, interpretability, and diagnostic accuracy than financial AI does on speed, anomaly detection, and low-latency inference. Only six research assessed the cross-domain transferability of AI models, despite conceptual similarities, suggesting a deficiency in compatible design principles.

6. Cross-Domain Synergies

In areas like billing, insurance, and health-fintech platforms, healthcare and financial systems converge. Fintech is the combination of traditional financial services and technology [33]. Fintech, or "financial technology," is one of the newest innovations. This technology is used to manage corporate operations in almost every industry, especially the financial sector. Its main objective is to improve the quality of financial services by utilizing information technology (IT) [34]. For example, AI can identify fraudulent claims and streamline underwriting procedures, while blockchain can support transparent health insurance claims. With AI producing insights for public health and preventive treatment, patients can also safely tokenize their health data using blockchain and profit from it in financial markets. For example, a data breach at Tampa General Hospital in the United States in May 2023 revealed some 2.1 million patient records; as a result, a $6.8 million class-action settlement was reached, with individual compensation reaching $7,500 [35].This kind of convergence is an example of how blockchain-AI ecosystems have the ability to cross industry borders and develop new hybrid enterprises. These cross-domain trends point to the development of a trust–intelligence continuum, in which AI acts as the layer that enables intelligence and blockchain acts as the substrate that enables trust. The two technologies' synergy promotes autonomous decision-making systems that cut across sectoral borders, operational transparency, and data authenticity.

The emergence of health-fintech ecosystems signals the start of a new field of research that focuses on collaborative governance, ethical AI, and data democratization.

Only four of the 53 included research examined cross-domain synergy between the financial and healthcare domains. None of the solutions assessed real-world multi-sector compatibility, and the majority function in siloed designs.

• Absence of AI benchmarking datasets for blockchain-integrated systems

• Few studies assess XAI for decisions based on blockchain.

• Absence of common standards to assess AI accuracy across industries

• Lack of extensive empirical support for AI+blockchain models

• Transformer and GNN designs in blockchain analytics have not received much attention.

Analytical Outlook

Although trust (blockchain) and intelligence (AI) share conceptual similarities, there is still no empirical support for cross-domain models. Benefits of interoperability, including decreased transaction latency or improved data reliability across domains, should be measured in comparative studies.

7. Challenges and Limitations of Blockchain–AI Convergence

Notwithstanding the promising future, scalability and cross-sector adoption are constrained by technological, ethical, and governance-related challenges associated with merging blockchain with AI.

1. **Scalability:** Both systems require a large amount of processing power. While AI models need large training datasets and processing capacity, blockchain throughput is constrained. Blockchain networks face difficulties with transaction throughput and data storage due to the time-consuming consensus process and the intrinsic limitations of block size. The viability and efficiency of large-scale applications are severely constrained by these limitations [26].
2. **Interoperability:** The smooth integration of hospitals, banks, and global markets is impeded by the absence of standardized frameworks.

3. **Data Privacy and Ethics:** The immutability of blockchain technology runs counter to laws like GDPR that require data erasure. Public, permissionless blockchains represent the greatest challenges in terms of GDPR compliance," according to a 2018 research from the EU Blockchain Observatory & Forum. [36]. AI simultaneously presents opacity and bias risks. When it comes to the use of artificial intelligence (AI), there are numerous privacy concerns as well as more general ethical concerns about both the individual and the systems' capacity to make decisions on their own that may affect the welfare of both individuals and larger groups [27].
4. **Regulatory Uncertainty:** Different jurisdictions handle blockchain assets and AI systems differently, which makes cross-border activities more difficult. In the era of digital globalization, cross-border data flow (CBDF) is becoming a crucial part of modern global supply chains. Multinational corporations like Alibaba and Infosys are able to provide highly tailored, data-driven services, automate financial transactions, integrate logistical operations, and transcend geographical boundaries thanks to these flows[38].
5. **Cost and Sustainability:** Deep learning models and energy-intensive blockchain consensus processes make environmental issues worse. Concerns about sustainability have been raised by its environmental impact, especially from energy-intensive consensus methods like Proof of Work (PoW) [28].

Categorization of Challenges

Category	Challenge	Description
Technical	Scalability and Interoperability	AI and blockchain both demand a lot of processing power. Real-time integration between healthcare and finance is hampered by blockchain's low transaction throughput and AI's high training requirements. Interoperability is further limited by the absence of standardized interfaces.
Ethical	Data Privacy and Algorithmic Bias	Blockchain's unchangeable nature clashes with privacy regulations like the GDPR, while artificial intelligence increases the possibility of bias and opacity in judgments. Fairness, responsibility, and compliance must be guaranteed by ethical governance.
Governance	Regulatory Uncertainty and Sustainability	The adoption of blockchain and AI across borders is complicated by inconsistent international legislation. Furthermore, sustainability issues are brought up by energy-intensive consensus methods and extensive AI training.

Integrative Reflection: A lot of issues are interconnected; ethical and legal limitations affect sustainability and scalability. Financial systems, such as AML and CBDC standards, are moving closer to regulatory coherence, according to comparative analysis, whereas healthcare is lagging behind because of disjointed data rules. Cross-sector governance frameworks must be used in future research to guarantee interoperability without sacrificing ethics.

Methodological Challenge: The lack of uniform evaluation metrics is a significant constraint found in the examined studies. Less than five studies addressed computational delay, while only 18 studies provided accuracy, 12 reported AUC, and 7 reported F1-score—despite the fact that blockchain settings by nature demand real-time performance assurances.

8. Research Gaps and Future Directions

Although conceptually intriguing, the analysis shows that governance structures, interoperability protocols, and empirical validation are still lacking in blockchain-AI integration.

• **Federated Blockchain–AI Models:** Research on combining federated learning and blockchain technology for decentralized finance and healthcare is lacking.

• **Explainable AI (XAI) in Blockchain Systems:** There is an urgent need for interpretable AI to boost confidence in important decisions.

• **Cross-Domain Applications:** Few research look at blockchain and AI systems that work together in the healthcare and financial sectors.

• **Scalable Architectures:** Research should concentrate on lightweight consensus techniques and efficient AI models for real-world application.

• **Ethics and Governance:** More attention needs to be paid to the socio-ethical elements of blockchain-AI ecosystems, such as ownership, accountability, and inclusivity.

The majority of blockchain–AI systems are still conceptual or prototype-level rather than operational, as evidenced by the fact that only four out of the 53 research attempted extensive empirical validation.

In order to verify scalability, transparency, and ethical compliance in practical settings, future research must transition from conceptual prototypes to empirical, cross-domain pilots. Together, these paths point to a paradigm shift away from descriptive convergence and toward blockchain–AI ecosystems that are operational and morally sound.

9. Conclusion

The intersection of blockchain technology and artificial intelligence (AI) signifies a significant socio-technical shift that is changing the fundamentals of value, intelligence, and trust in digital ecosystems. Artificial intelligence (AI) is a technology that has the ability to surpass human capabilities by performing intricate jobs that call for human intelligence[40].Artificial intelligence (AI) and blockchain (BC) technologies are used independently in a variety of sectors, such as banking, finance, and healthcare [41]. It goes beyond simple technological integration. This combination is fostering previously unheard-of innovation in the banking and healthcare industries, boosting fraud detection, facilitating transparent and real-time financial transactions, guaranteeing safe exchange of medical data, advancing diagnostics, and fortifying pharmaceutical supply chains. Recent advances in AI techniques have had a significant impact on healthcare, even igniting a heated debate on whether or not AI physicians may eventually take the place of human doctors [42].

Notwithstanding these developments, a number of obstacles still exist, such as limitations on scalability, gaps in interoperability, changing legal environments, and urgent ethical issues pertaining to algorithmic bias, privacy, and responsibility. However, there is also widespread consensus that these technologies threaten democracies, increase monopolies, increase inequality, pose privacy risks, and increase misinformation, fraud, bias, and safety issues. As a result, regulatory mechanisms are needed to limit the negative effects of these technologies [43]. In addition to technical improvement, addressing these problems calls for a comprehensive governance structure that takes social, legal, and ethical viewpoints into account.

This systematic review makes a contribution by outlining the present status of blockchain-AI integration, pointing out cross-domain uses, and suggesting a thorough research agenda with an emphasis on sustainability, explainability, and interoperability. An actionable research path is provided by this review, which is one of the first systematic cross-sector syntheses of blockchain–AI integration across healthcare and finance infrastructures. Continued interdisciplinary cooperation between engineers, legislators, and ethicists is necessary for future advancement in order to guarantee that blockchain–AI ecosystems are safe, open, and socially conscious. By creating intelligent, reliable, and robust infrastructures for the upcoming financial and healthcare systems, this convergence has the revolutionary potential to completely change the digital era when properly utilized.

This paper highlights the potential of AI techniques in a variety of industries, including healthcare and finance, by offering a structured taxonomy and comparative evaluation of these methods working inside blockchain-enabled infrastructures. The results also demonstrate that these methods' maturity is still unequal, highlighting the necessity of validated datasets, defined benchmarks, and explainable, federated, and scalable AI systems to facilitate real-world deployment.

Table 1
Blockchain and AI Applications in Healthcare

Area	Blockchain Role	AI Role	Benefits
Medical Data Security	Immutable EHRs	Predictive analytics & modeling	Trustworthy decision support
Diagnostics & Imaging	Secure data sharing	Image recognition, predictive modeling	Reduced bias, improved outcomes
Drug Supply Chain	Provenance & trace	Forecasting, anomaly detection	Counterfeit prevention, efficiency
Telemedicine	Identity & security	Personalized treatment, monitoring	Safer, accessible remote healthcare

Table 2
Uses of Blockchain and AI in Financial Systems

Area	Blockchain Role	AI Role	Benefits
Fraud Detection	Immutable records	Anomaly detection	Reduced fraud, improved market trust
Digital Banking	Decentralized payments	Customer analytics	Faster, cheaper, transparent services
AML & Compliance	Auditable trails	Suspicious activity detection	Strengthened regulatory frameworks
CBDCs& Cryptocurrency	Secure ledger	Forecasting, market analysis	Stable, intelligent currency ecosystems

Declarations

Acknowledgment

Throughout the development of this study, the authors would like to sincerely thank the Department of Computer Science and Engineering at the Islamic University in Kushtia, Bangladesh, for providing ongoing academic guidance, institutional support, and a supportive research environment. “Artificial Intelligence Techniques in Blockchain-Integrated Healthcare and Financial Systems: A Systematic Review and Future Research Agenda.”

The authors also acknowledge the academic resources, research facilities, and support from Zhengzhou University in China and the Bangladesh Open University, which were crucial to this study.

Finally, the authors would like to express their gratitude to the academic staff and colleagues for their indirect support in completing this study.

Funding Declaration

For this study, no specific grant or financing from public, commercial, or nonprofit organizations was obtained.

Data Availability Statement

This study does not generate or analyze any new data. Data sharing is therefore not relevant to this subject.

Conflict of Interest

The authors affirm that none of the work described in this manuscript may have been impacted by any known financial or personal conflicts of interest.

Acknowledgment

Throughout the development of this study, the authors would like to sincerely thank the Department of Computer Science and Engineering at the Islamic University in Kushtia, Bangladesh, for providing ongoing academic guidance, institutional support, and a supportive research environment. “Artificial Intelligence Techniques in Blockchain-Integrated Healthcare and Financial Systems: A Systematic Review and Future Research Agenda.”

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Figures

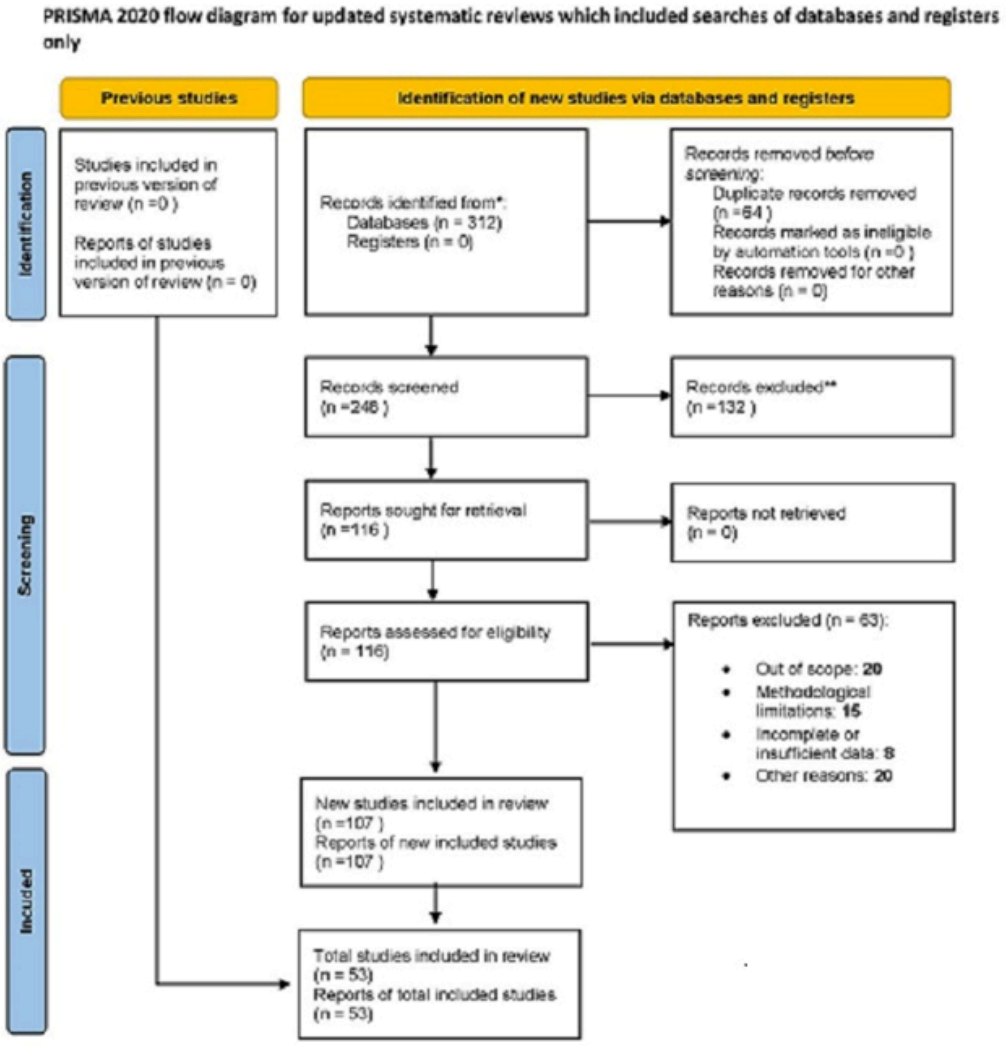


Figure 1

PRISMA-style flow diagram showing research selection process.