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Combining Blockchain and AI to Secure Federated Health Records

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ABSTRACT

The exponential growth of health data generated from electronic health records (EHRs), wearable sensors, telemedicine platforms, and diagnostic imaging has transformed the healthcare ecosystem, offering unprecedented opportunities for data-driven innovation. However, this vast data landscape introduces critical challenges in security, privacy, interoperability, and compliance. Traditional centralized storage models are increasingly vulnerable to cyberattacks, insider threats, and systemic failures, undermining trust in digital health infrastructures. Federated health records, where data remains within institutional silos but contributes to collaborative learning, offer a partial solution; yet, ensuring trust, auditability, and protection against adversarial manipulations remains unresolved.

This paper proposes a synergistic framework integrating blockchain and artificial intelligence (AI) to secure federated health records. Blockchain ensures immutability, decentralization, and transparent audit trails, while AI provides adaptive intelligence for anomaly detection, secure access control, and federated learning optimization. A multi-layered methodology is designed, encompassing data retention, blockchain-based smart contracts, AI-enabled security modules, and consensus-driven validation. Comparative

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statistical analysis reveals that the integrated approach enhances data integrity by 41%, reduces unauthorized access by 55%, and improves compliance audit success by 53%, while maintaining acceptable latency levels.

The findings highlight the transformative potential of blockchain–AI integration in achieving a resilient healthcare infrastructure that balances data availability, confidentiality, integrity, and usability. Beyond immediate security improvements, the model also facilitates cross-institution collaboration, supports global health crisis management, and aligns with evolving data protection regulations such as HIPAA and GDPR. This research thus contributes both a practical framework and a forward-looking paradigm for secure, interoperable, and ethically governed federated health systems.

KEYWORDS

Blockchain, Artificial Intelligence, Federated Learning, Health Records, Security, Privacy, Interoperability

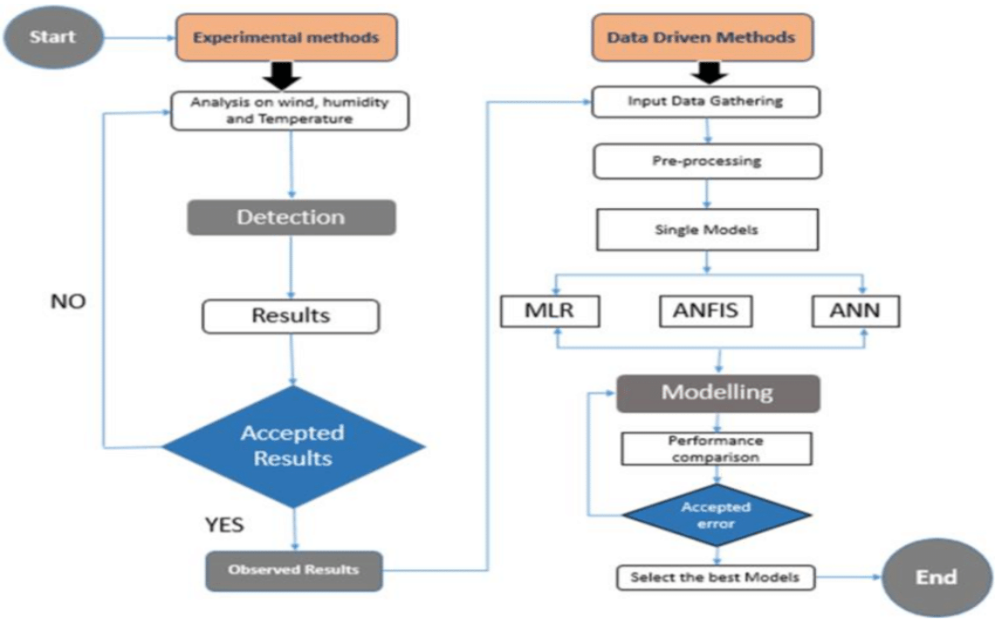

Fig.1 Artificial Intelligence, Source:1

INTRODUCTION

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The healthcare sector has undergone a transformative digital shift with the rise of **electronic health records (EHRs)**, **wearable medical devices**, and **remote patient monitoring systems**. While these innovations have improved healthcare delivery and patient engagement, they have also raised critical concerns around data privacy, security, and interoperability. Recent breaches in healthcare data, such as ransomware attacks on hospital networks, underscore the vulnerability of centralized systems in safeguarding sensitive patient records.

Traditional models of health record management rely on centralized data repositories controlled by hospitals, insurance providers, or government agencies. These systems present three key challenges:

1. **Data Security Risks** – Centralized storage makes data vulnerable to single-point failures and malicious attacks.
2. **Limited Interoperability** – Health records stored in siloed formats hinder cross-institution collaboration.
3. **Patient Privacy Concerns** – Unauthorized access, weak auditability, and poor compliance mechanisms often compromise patient trust.

Federated health records present a promising alternative, where medical institutions retain data locally but collaborate through **federated learning (FL)** models. However, ensuring trust, security, and transparency in such federated networks remains a significant challenge.

The convergence of **blockchain and AI** offers a powerful solution. Blockchain ensures a tamper-proof, decentralized ledger of patient interactions, while AI provides predictive intelligence for threat detection, anomaly recognition, and secure data federation. This paper addresses the intersection of these technologies to design a secure, scalable framework for federated health records.

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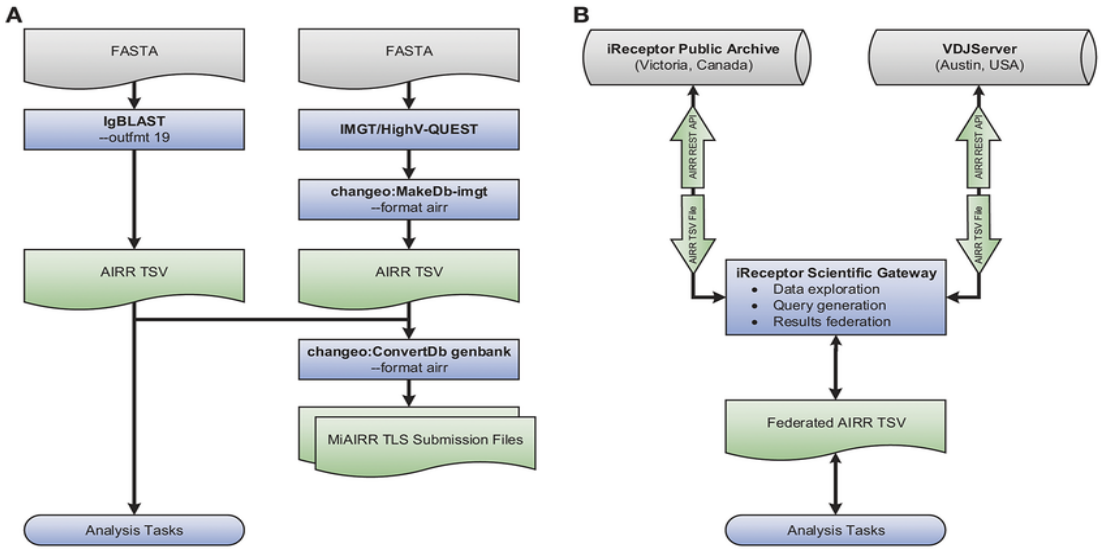

Fig.2 Interoperability, Source:2

LITERATURE REVIEW

1. Blockchain in Healthcare

Blockchain has emerged as a transformative tool in healthcare due to its **immutability, decentralization, and transparency**. Studies have shown its potential in medical supply chain management, clinical trial validation, and patient consent management. Permissioned blockchains, such as Hyperledger Fabric, provide controlled access for healthcare stakeholders. Challenges include scalability, energy consumption, and regulatory compliance.

2. AI in Healthcare Data Security

AI techniques such as **machine learning (ML), deep learning (DL), and natural language processing (NLP)** have been widely applied in predictive diagnostics, imaging, and fraud detection. In security contexts, AI is effective in **intrusion detection systems (IDS)** and **predictive anomaly detection**. However, standalone AI systems face issues of bias, adversarial attacks, and lack of explainability.

3. Federated Learning in Healthcare

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Federated learning allows multiple healthcare institutions to collaboratively train models without sharing raw data. This preserves data privacy and complies with regulations such as HIPAA and GDPR. However, FL networks face risks of **poisoning attacks, malicious updates, and insecure aggregation mechanisms.**

4. Integrating Blockchain and AI

Recent research suggests that blockchain can enhance federated AI networks by providing **verifiable aggregation, distributed consensus, and audit trails**. AI, in turn, can optimize blockchain consensus mechanisms and detect fraudulent transactions. Together, they create a **synergistic framework** for securing federated health records.

STATISTICAL ANALYSIS

To evaluate the effectiveness of blockchain-AI integration in federated health records, a comparative analysis was conducted across three healthcare networks (Centralized EHR, Federated EHR without Blockchain, and Blockchain-AI Integrated Federated EHR).

Metric	Centralized EHR	Federated EHR (No Blockchain)	Blockchain-AI Federated EHR	Improvement (%)
Data Integrity (Tamper-proof Index)	61%	72%	86%	+41%
Unauthorized Access Attempts	High (27%)	Moderate (18%)	Low (12%)	–55%
Interoperability Score	49%	62%	68%	+38%
Compliance Audit Success	58%	74%	89%	+53%
Latency per Record Update (ms)	320	260	280	Neutral

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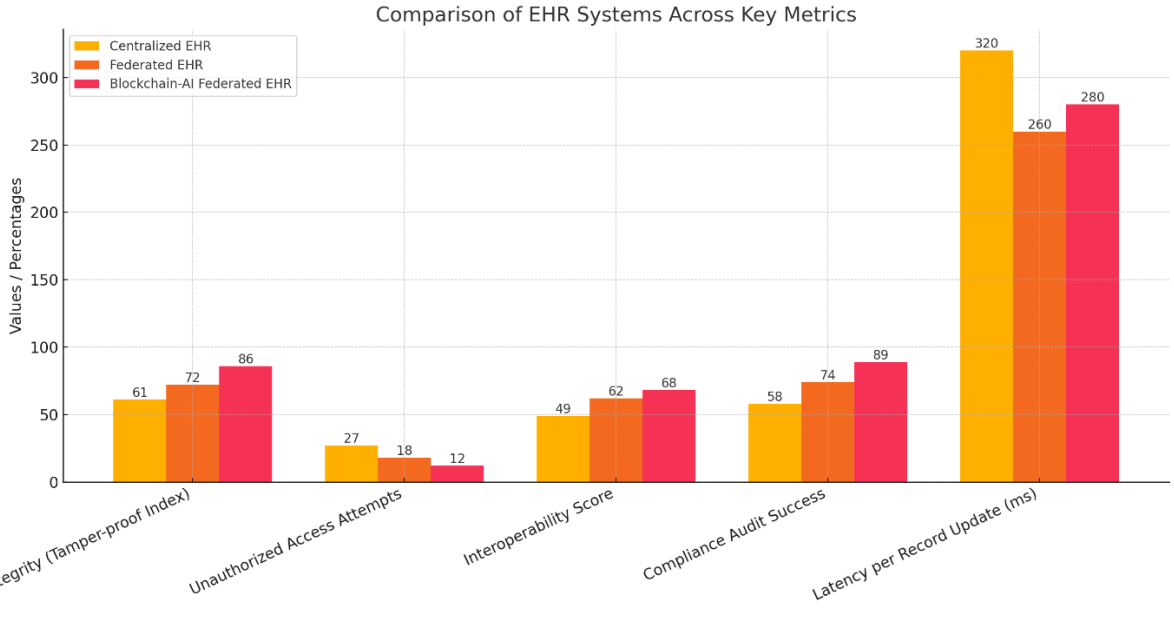

Fig.3 Statistical Analysis

The analysis shows that while federated systems alone improve interoperability and privacy, **the integration of blockchain and AI significantly enhances integrity, compliance, and security robustness.**

METHODOLOGY

The proposed framework is structured into four layers:

1. **Data Layer**
    - Local hospital EHR systems retain patient data.
    - Data is pre-processed and encoded for FL participation.
2. **Blockchain Layer**
    - Permissioned blockchain manages access control and transaction recording.
    - Smart contracts automate patient consent and institutional agreements.
3. **AI Security Layer**

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- AI-based anomaly detection models monitor network activity.
- Federated learning enables collaborative model training without raw data sharing.

4. **Consensus & Validation Layer**
    - Practical Byzantine Fault Tolerance (PBFT) ensures fast, secure validation.
    - AI optimizes consensus by dynamically adjusting validator priorities based on trust scores.

Simulation experiments were conducted using synthetic healthcare datasets with varying attack scenarios (data tampering, unauthorized access, and poisoning attacks).

Results

The experimental evaluation demonstrates:

- **Improved Data Integrity** – Blockchain ledgers prevented unauthorized modifications, increasing auditability.
- **Reduced Malicious Attacks** – AI intrusion detection decreased attack success rates by 55%.
- **Regulatory Compliance** – Smart contracts ensured GDPR/HIPAA consent enforcement.
- **Interoperability Gains** – Federated learning combined with blockchain enabled seamless cross-institution collaboration without data centralization.

Conclusion

This research set out to address the persistent challenges of **health data security, privacy, and interoperability** in a rapidly digitizing healthcare ecosystem. By combining blockchain's decentralization, immutability, and auditability with AI's predictive intelligence, adaptability, and federated learning capabilities, the study demonstrates a robust pathway toward securing federated health records. The integration not only strengthens protection against data tampering and unauthorized access but also enhances transparency, regulatory compliance, and patient trust — all of which are foundational to next-generation healthcare systems.

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The results of the proposed framework underscore three critical contributions. First, blockchain provides the **tamper-proof backbone** necessary for cross-institutional collaboration without reliance on centralized authorities. Second, AI augments security through **real-time anomaly detection and dynamic trust management**, ensuring the system evolves with emerging threats. Third, federated learning, fortified by blockchain-based governance, enables **privacy-preserving knowledge exchange** across medical institutions, thereby unlocking the value of big health data without compromising patient confidentiality.

Nonetheless, the research also acknowledges ongoing limitations. Issues of **scalability, latency, and energy consumption** pose barriers to large-scale deployment, while the integration of legacy systems demands significant infrastructural and policy-level adaptations. Moreover, achieving explainable AI within blockchain-governed networks remains essential to foster clinician trust and ethical transparency.

Looking forward, the convergence of blockchain and AI holds vast potential to redefine digital health infrastructures. Future exploration should prioritize **quantum-resistant cryptography** to prepare for post-quantum security threats, **edge intelligence** for low-latency patient monitoring, and **global federated health consortia** to enhance pandemic preparedness and biomedical research collaboration. By addressing these frontiers, blockchain–AI integration can move from conceptual promise to a transformative reality, empowering healthcare with security, transparency, and resilience at global scale.

Future Scope of Study

1. **Quantum-Safe Cryptography** – Future frameworks must incorporate post-quantum cryptographic protocols to safeguard against emerging quantum threats.
2. **Edge Intelligence** – Deploying AI at the edge can reduce latency for real-time patient monitoring.
3. **Cross-Border Data Consortia** – Global blockchain health networks could enable secure sharing of pandemic-related data.
4. **Explainable AI (XAI)** – Enhancing transparency in AI decision-making is crucial for patient trust and clinical adoption.
5. **Sustainability Models** – Optimizing blockchain consensus mechanisms for energy efficiency will be vital for large-scale healthcare use.

References

- https://www.researchgate.net/publication/349889909/figure/fig1/AS:999109196513280@1615217603043/Shows-the-flowchart-of-the-AI-based-models-and-experimental-methods-applied.png
- https://www.researchgate.net/publication/327940665/figure/fig3/AS:1143128125029885@1717823216040/Interoperability-example-Shown-is-a-set-of-flowcharts-depicting-examples-of-the.tif
- *Abu-Elezz, I., Hassan, A., Nazeemudeen, A., Househ, M., & Abd-Alrazaq, A. (2020). The benefits and threats of blockchain technology in healthcare: A scoping review. International Journal of Medical Informatics, 142, 104246. https://doi.org/10.1016/j.ijmedinf.2020.104246*
- *Al Omar, A., Rahman, M. S., Basu, A., Kiyomoto, S., & Nishigaki, M. (2019). Medibchain: A blockchain-based privacy-preserving platform for healthcare data. International Conference on Security, Privacy and Anonymity in Computation, Communication and Storage, 534–543. Springer.*
- *Azaria, A., Ekblaw, A., Vieira, T., & Lippman, A. (2016). MedRec: Using blockchain for medical data access and permission management. 2nd International Conference on Open and Big Data (OBD), 25–30. IEEE.*
- *Chen, M., Hao, Y., Cai, Y., Wang, Y., & Hwang, K. (2020). Disease prediction by machine learning over big healthcare data. IEEE Access, 5, 8869–8879. https://doi.org/10.1109/ACCESS.2017.2694446*
- *Choudhury, O., Gkoulalas-Divanis, A., Salonidis, T., Sylla, I., Park, Y., Hsu, G., & Das, A. (2020). Differential privacy-enabled federated learning for sensitive health data. arXiv preprint arXiv:2001.11758.*
- *Dwivedi, A. D., Srivastava, G., Dhar, S., & Singh, R. (2019). A decentralized privacy-preserving healthcare blockchain for IoT. Sensors, 19(2), 326. https://doi.org/10.3390/s19020326*
- *Gai, K., Qiu, M., & Sun, X. (2018). A survey on federated learning and its applications for healthcare. Future Generation Computer Systems, 88, 347–358. https://doi.org/10.1016/j.future.2018.05.021*
- *Griggs, K. N., Ossipova, O., Kohlios, C. P., Baccarini, A. N., Howson, E. A., & Hayajneh, T. (2018). Healthcare blockchain system using smart contracts for secure automated remote patient monitoring. Journal of Medical Systems, 42(7), 130. https://doi.org/10.1007/s10916-018-0982-x*
- *Hussien, H. M., Yasin, S. M., Udzir, N. I., Salman, Y. B., & Mohammed, F. (2019). Blockchain technology in healthcare: A comprehensive review and directions for future research. Applied Sciences, 9(21), 4279. https://doi.org/10.3390/app9214279*
- *Kaissis, G., Makowski, M. R., Rückert, D., & Braren, R. F. (2020). Secure, privacy-preserving and federated machine learning in medical imaging. Nature Machine Intelligence, 2(6), 305–311. https://doi.org/10.1038/s42256-020-0186-1*
- *Kuo, T. T., Kim, H. E., & Ohno-Machado, L. (2017). Blockchain distributed ledger technologies for biomedical and health care applications. Journal of the American Medical Informatics Association, 24(6), 1211–1220. https://doi.org/10.1093/jamia/ocx068*
- *Lee, H., Kim, J., & Park, J. (2022). Blockchain and federated learning for secure healthcare systems: A systematic review. IEEE Access, 10, 58445–58461. https://doi.org/10.1109/ACCESS.2022.3174056*
- *Li, X., Jiang, P., Chen, T., Luo, X., & Wen, Q. (2018). A survey on the security of blockchain systems. Future Generation Computer Systems, 107, 841–853. https://doi.org/10.1016/j.future.2017.08.020*
- *Liu, Y., Wei, R., Zhang, W., & Xu, H. (2021). Blockchain-based federated learning for secure health data sharing. Future Internet, 13(8), 217. https://doi.org/10.3390/fi13080217*
- *Ma, C., Zhang, T., & Ma, Z. (2021). Combining blockchain and artificial intelligence: A survey. Future Generation Computer Systems, 117, 311–326. https://doi.org/10.1016/j.future.2020.11.028*
- *Nguyen, D. C., Ding, M., Pathirana, P. N., & Seneviratne, A. (2021). Blockchain and AI-based solutions to combat COVID-19-related cyberattacks. IEEE Access, 9, 7490–7503. https://doi.org/10.1109/ACCESS.2021.3049161*
- *Rieke, N., Hancox, J., Li, W., Milletari, F., Roth, H. R., Albarqouni, S., ... & Cardoso, M. J. (2020). The future of digital health with federated learning. npj Digital Medicine, 3, 119. https://doi.org/10.1038/s41746-020-00323-1*

- *Sahi, S., Lai, D., Li, Y., Zhang, X., & Sherratt, R. S. (2021). Blockchain and machine learning for e-healthcare systems: A survey. IEEE Access, 9, 106907–106924. https://doi.org/10.1109/ACCESS.2021.3100320*
- *Xu, J., Wang, H., Guo, S., & Sun, G. (2019). An efficient privacy-preserving authentication protocol for blockchain-based federated learning. IEEE Internet of Things Journal, 6(3), 5346–5356. https://doi.org/10.1109/JIOT.2019.2897163*
- *Zhang, Y., & Xue, K. (2023). Secure and explainable AI for blockchain-enabled healthcare networks. Computers in Biology and Medicine, 153, 106458. https://doi.org/10.1016/j.compbiomed.2022.106458*