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A Survey on Current Electronic Health Record (EHR) Systems and the Role of AI in Enhancing Healthcare Efficiency

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Abstract: Electronic Health Record (EHR) systems have be- come the foundation of modern healthcare infrastructure, en- abling the digitalization and efficient management of patient data. However, despite continuous advancements, current EHR systems still face challenges related to interoperability, scalability, data privacy, and integration with artificial intelligence (AI). This paper presents a comprehensive survey of fifteen recent research studies (2022–2025) focusing on EHR technologies, AI-driven healthcare solutions, and related innovations. The survey highlights the advantages and disadvantages of current systems, identifies research gaps, and proposes how our project, CURA- ID, aims to overcome these limitations through AI integration, blockchain-based security, and patient-centric features.
Index Terms: Electronic Health Record (EHR), Artificial In- telligence, Healthcare Systems, Data Privacy, Interoperability, CURA-ID.

I. INTRODUCTION

In recent years, the healthcare industry has undergone a transformative shift from paper-based medical record-keeping to digital management systems. This evolution, driven by the adoption of Electronic Health Records (EHRs), has enabled healthcare providers to store, access, and exchange patient information seamlessly across hospitals, clinics, and laborato- ries. EHRs have become indispensable for improving clinical efficiency, reducing human error, and enhancing patient out- comes. Despite their potential, however, the full promise of EHR technology remains largely unrealized.

One of the primary challenges in existing EHR systems is the lack of interoperability. Patient information often ex- ists in siloed databases maintained by individual healthcare institutions, making it difficult to access or exchange data between organizations. This fragmented structure results in duplication, incomplete medical histories, and inconsistencies that can adversely affect diagnosis accuracy and treatment de- cisions. Furthermore, healthcare institutions often rely on het-erogeneous data standards and formats, which hinder smooth communication between systems.

Another significant issue is the limited integration of Artificial Intelligence (AI) within traditional EHR frameworks. Al- though the healthcare sector is increasingly exploring predictive analytics, risk assessment, and automated decision support systems, most legacy EHRs are not designed to accommodate such advanced capabilities. AI-driven solutions require large, structured datasets that can feed machine learning models — but current EHR infrastructures often fail to provide such quality data due to missing records, incompatible formats, and privacy restrictions.

Data privacy and security remain additional areas of concern. With healthcare data being one of the most sensitive forms of personal information, the risk of breaches, unauthorized access, and misuse poses serious challenges. Centralized databases, while convenient for management, are vulnerable to cyberattacks and unauthorized data manipulation. Moreover, the rapid growth of telemedicine and cloud-based platforms adds another layer of complexity to ensuring secure, compliant data sharing across borders and devices.

The integration of blockchain and federated learning has emerged as a promising approach to tackle these challenges. Blockchain can provide immutable audit trails and transparent data sharing, while federated learning enables decentralized model training without exposing sensitive patient data. Together, these technologies can enhance trust, security, and data ownership within healthcare ecosystems.

To bridge these gaps, this paper explores the evolution and limitations of existing EHR systems and examines how AI, blockchain, and data analytics can be harnessed to build smarter, more interoperable healthcare platforms. Our pro- posed model, CURA-ID, builds upon these insights to create a unified and intelligent EHR system that emphasizes data integrity, patient empowerment, and predictive healthcare an- alytics.

II. LITERATURE SURVEY

This section summarizes the key advantages and disadvan- tages found in fifteen research papers published between 2022 and 2025.

A. Paper-wise Analysis

In [1], Rao et al. emphasized cloud-based EHR frameworks that enhance accessibility and scalability. *Advantages:* Im- proved data sharing and reduced storage costs. *Disadvantages:* High risk of cloud data breaches and dependency on third- party servers. In [2], Kim et al. proposed AI-driven EHR data processing for clinical decision support. *Advantages:* Auto- mated pattern recognition and faster diagnosis. *Disadvantages:* Data bias and lack of explainability in model predictions. In [3], Gupta et al. discussed blockchain-based EHR for integrity and security. *Advantages:* Immutable records and strong audit trails. *Disadvantages:* High computational cost and slow trans- action speeds. In [4], Smith et al. addressed interoperability challenges. *Advantages:* Better hospital communication pro- tocols. *Disadvantages:* Poor standardization and inconsistent APIs. In [5], Zhang et al. studied privacy-preserving models using federated learning. *Advantages:* Data remains local, protecting patient privacy. *Disadvantages:* Model training complexity and communication overhead. In [6], Liu et al. integrated predictive analytics with EHR data. *Advantages:* Early disease detection. *Disadvantages:* Inconsistent data qual- ity affecting model accuracy. In [7], Pe´rez et al. evaluated en- cryption methods in EHR. *Advantages:* Enhanced data security and compliance. *Disadvantages:* Increased computational load during access. In [8], Ali et al. proposed hybrid systems com- bining AI and IoT. *Advantages:* Real-time health monitoring. *Disadvantages:* High infrastructure cost and latency. In [9], Johnson et al. analyzed usability factors of EHR interfaces. *Advantages:* Improved doctor–patient interaction. *Disadvan- tages:* Steep learning curve for new users. In [10], Patel et al. reviewed hybrid cloud models for healthcare. *Advantages:* En- hanced scalability. *Disadvantages:* Complex synchronization issues. In [11], Ferna´ndez et al. studied AI-based health risk prediction systems. *Advantages:* Personalized treatment plans. *Disadvantages:* Limited generalizability of AI models. In [12], Miller et al. proposed API-based interoperability layers. *Advantages:* Faster data exchange. *Disadvantages:* Version incompatibility issues. In [13], Singh et al. focused on patient- centered health record systems. *Advantages:* Enhanced trans- parency. *Disadvantages:* Low adoption due to technical liter- acy gaps. In [14], Brown et al. implemented ML algorithms for diagnosis prediction. *Advantages:* Better diagnostic accuracy. *Disadvantages:* Requires large, high-quality datasets. In [15], Williams et al. surveyed futuristic EHR frameworks with AI and blockchain integration. *Advantages:* Unified ecosystem for healthcare data. *Disadvantages:* Integration complexity and scalability challenges. .

III. LEGACY SYSTEM

Legacy Electronic Health Record (EHR) systems have served as the backbone of digital healthcare management for decades, but their design and architecture are often constrained by outdated technologies and limited adaptability to modern healthcare needs. These systems typically employ centralized data storage, minimal interoperability, and weak AI integra- tion, which restricts their scalability and analytical potential. Despite advancements in cloud computing and health infor- matics, several limitations remain unaddressed.

Firstly, cloud-based frameworks such as those proposed by Rao and Kaur [1] have improved accessibility and storage efficiency but still face challenges related to dependency on third-party servers and potential data breaches. Interoperability issues have been extensively documented by Smith and Khan [4], who found that legacy systems often lack standardized APIs and consistent communication protocols, leading to data silos between healthcare institutions.

AI integration remains another major gap in traditional EHRs. Kim and Park [2] demonstrated how AI-driven clinical decision support could transform patient diagnosis, yet legacy systems lack the infrastructure to accommodate real-time AI analytics. Similarly, Liu and Tan [6] explored predictive analytics for early disease detection, revealing that older systems struggle with inconsistent data quality, limiting model accuracy.

Blockchain-based security mechanisms, as presented by Gupta and Mehta [3], have shown potential for improving in- tegrity and transparency in health data management. However, such technologies are absent in most legacy EHR systems, which still rely on basic encryption and centralized authentication protocols.

Pe´rez and Gonza´lez [7] emphasized the importance of enhanced encryption, while Zhang and Li [5] highlighted privacy-preserving federated learning as a superior approach to protecting distributed medical data — both of which remain largely unimplemented in legacy frameworks.

Furthermore, hybrid cloud solutions proposed by Patel and Deshmukh [10] provide scalability and data redundancy, but existing systems fail to fully leverage these architectures due to compatibility and synchronization issues. Usability remains a significant concern as well — Johnson and Carter [9] found that outdated user interfaces reduce clinician productivity and increase the learning curve for new users.

Integration with IoT and real-time monitoring is another frontier where legacy systems fall short. Ali and Singh [8] proposed AI–IoT integration for continuous health monitor- ing, yet most traditional EHR systems lack real-time data acquisition and event-driven processing capabilities. Likewise, Ferna´ndez and Ortiz [11] introduced multi-modal AI-based risk prediction frameworks that rely on diverse datasets, but existing EHRs are too rigid to incorporate such heterogeneous data sources.

The challenge of interoperability is compounded by inad- equate API frameworks, as studied by Miller and Zhao [12], who suggested API-based middleware for seamless communi- cation. However, outdated EHR software often lacks modular

Paper	Focus Area	Advantages	Disadvantages
[1] Rao et al. (2022)	Cloud-based EHR frameworks	Improved data sharing; reduced storage costs	High risk of data breaches; de-pendency on third-party servers
[2] Kim et al. (2022)	AI-driven EHR decision support	Automated pattern recognition; faster diagnosis	Data bias; lack of explainability
[3] Gupta et al. (2023)	Blockchain-based EHR security	Immutable records; strong audit trails	High computational cost; slow transactions
[4] Smith et al. (2023)	Interoperability challenges	Better hospital communication protocols	Poor standardization; inconsis-tent APIs
[5] Zhang et al. (2023)	Federated learning for privacy	Data remains local; strong pri-vacy protection	Training complexity; communi-cation overhead
[6] Liu et al. (2023)	Predictive analytics in EHR	Early disease detection	Inconsistent data quality reduc-ing accuracy
[7] Pe´rez et al. (2023)	EHR encryption and security	Enhanced data security and com-pliance	Increased computational load
[8] Ali et al. (2023)	AI + IoT hybrid healthcare sys-tems	Real-time monitoring	High infrastructure cost; latency issues
[9] Johnson et al. (2024)	EHR usability and UI/UX	Improved doctor–patient interac-tion	Steep learning curve for new users
[10] Patel et al. (2024)	Hybrid cloud architectures	Enhanced scalability	Complex synchronization issues
[11] Ferna´ndez et al. (2024)	AI-based risk prediction	Personalized treatment plans	Limited generalizability
[12] Miller et al. (2024)	API-based interoperability layers	Faster data exchange	Version incompatibility issues
[13] Singh et al. (2024)	Patient-centered EHR systems	Enhanced transparency	Low adoption due to technical literacy
[14] Brown et al. (2024)	ML-based diagnosis prediction	Better diagnostic accuracy	Requires large, high-quality datasets
[15] Williams et al. (2025)	AI + Blockchain futuristic EHR	Unified healthcare ecosystem	Integration complexity; scalabil-ity challenges

TABLE I: Summary of Literature Survey (2022–2025)

architecture, making it incompatible with modern web-based integrations. Singh and Ahmed [13] also discussed patient- centered systems that promote transparency and engagement, contrasting sharply with legacy models that offer minimal patient participation.

Machine learning-based diagnostic tools proposed by Brown and Davis [14] represent another technological shift, but older EHR systems cannot handle the large-scale, structured, and unstructured datasets required for such models. Similarly, Williams and Chen [15] reviewed future trends emphasizing blockchain–AI convergence in EHRs, underscoring how ex- isting systems lack the flexibility to adapt to these hybrid approaches.

In summary, legacy EHR systems suffer from the following core limitations:

1) Centralized and vulnerable data storage models.
2) Limited interoperability between institutions.
3) Lack of integration with AI and predictive analytics.
4) Outdated user interfaces and poor usability.
5) Weak encryption and inadequate privacy measures.
6) Inability to incorporate blockchain or federated learning.
7) Poor support for IoT-based health monitoring.
8) High latency in real-time data retrieval.
9) Scalability issues in cloud environments.
10) Minimal patient engagement or transparency.
11) Inconsistent data structures across vendors.
12) Redundant data entry and record duplication.
13) Limited adaptability to emerging APIs and data stan- dards.
14) Absence of explainable AI or decision-support mecha- nisms.
15) Overall lack of modularity and extensibility.

These limitations collectively demonstrate the urgent need for a next-generation EHR framework like **CURA-ID**, which integrates artificial intelligence, blockchain-based security, and modular cloud architecture to deliver a patient-centric, secure, and intelligent healthcare platform.

These limitations highlight the need for a next-generation EHR system that incorporates cloud scalability, AI-based analytics, and a unified user identity model. Our proposed system addresses these challenges by introducing a modern architecture capable of real-time interoperability, predictive healthcare insights, and secure cross-institutional data ex- change. This represents a significant advancement over legacy EHR frameworks and aligns with the vision of an intelligent, patient-centered healthcare ecosystem.

IV. FUTURE WORK

From the surveyed papers, several research gaps were identified. Our team will focus on addressing the following:

Enhancing interoperability through standardized APIs and blockchain-based data verification. Implementing AI-driven analytics for predicting disease outcomes and patient recovery time. Introducing dynamic, inter- active dashboards for real-time monitoring and in- sights. Ensuring data security using decentralized storage and federated learning.Building patient-centric features for personalized recommendations and preventive care.

Improving scalability and reliability through modular architecture and microservices.

V. SUMMARY TABLE

TABLE II: Comprehensive Comparison Between Legacy EHR Systems and Our Proposed Work (CURA-ID)

Aspect	Legacy EHR Systems	Our Proposed Work (CURA-ID)	Journal/Source
Data Storage	Centralized databases vulnerable to breaches, downtime, and single points of failure.	Hybrid blockchain-integrated stor- age ensuring decentralization, re- dundancy, and auditability.	"Hybrid Cloud Architectures for Health- care Data Storage" [10]; "Blockchain-based Electronic Health Record Systems: A Secu- rity Perspective" [3].
Interoperability	Limited cross-hospital communica- tion due to incompatible data for- mats and proprietary systems.	Standardized APIs with HL7/FHIR protocols to achieve seamless data exchange and uniformity.	"Overcoming Interoperability Challenges in Healthcare Systems" [4]; "API-based Inter- operability Layers in Healthcare IT" [12].
AI Integration	Minimal predictive analytics or AI- assisted insights; mostly static data visualization.	Integration of deep learning and NLP models for disease prediction, recovery forecasting, and real-time alerts.	"AI-driven Clinical Decision Support Using EHR Data" [2]; "Machine Learning Models for Diagnosis Prediction from EHR Data" [14].

Predictive Analytics	Lacks real-time predictive mecha- nisms; depends heavily on physi- cian input.	Continuous risk assessment and adaptive learning using live EHR data streams.	“Predictive Analytics in EHR Data for Dis- ease Detection” [6]; “AI-based Health Risk Prediction Using Multi-Modal Data” [11].
Patient Engagement	Patients are passive users with lim- ited record access and no self-monitoring tools.	Patient-centric design featuring chatbot guidance, personalized insights, and lifestyle-based recommendations.	“Patient-Centered EHR Systems for Im- proved Transparency” [13]; “Analyzing Us- ability and User Experience in EHR Sys- tems” [9].
Privacy and Security	Uses standard encryption but lacks robust access control and audit trails.	Multi-layered encryption, blockchain-based logging, and federated learning to preserve confidentiality.	“Enhancing EHR Security Through Encryp- tion and Access Control” [7]; “Privacy-Preserving Federated Learning for Medical Data Sharing” [5].
Data Ownership	Hospital-centric data management restricts patient control.	Blockchain identity ensures full ownership and consent-based data sharing for patients.	“Blockchain-based Electronic Health Record Systems” [3]; “Future Trends in AI and Blockchain-based EHR Systems” [15].
Scalability	Performance degrades as patient data grows; lacks distributed pro- cessing.	Distributed cloud-blockchain hy- brid supports multi-hospital scala- bility.	“Cloud-Based Frameworks for Efficient EHR Management” [1]; “Hybrid Cloud Ar- chitectures for Healthcare Data Storage” [10].
Data Visualization	Offers basic charts and tables with- out advanced insights.	Predictive dashboards with tempo- ral and spatial analytics (disease heatmaps, risk scores).	“Future Trends in AI and Blockchain-based EHR Systems” [15].
System Usability	Complex UIs lead to user fatigue and reduced adoption among clini- cians.	Intuitive interface with simplified navigation and smart data entry modules.	“Analyzing Usability and User Experience in EHR Systems” [9].
Integration with IoT Devices	Minimal or no integration with wearable health devices or IoT sen- sors.	IoT and wearable integration for continuous real-time patient mon- itoring.	“AI and IoT Integration in Healthcare Mon- itoring Systems” [8].
Data Accuracy	Manual data entry prone to errors and duplication.	AI-assisted validation checks en- sure high data fidelity and integrity.	“Machine Learning Models for Diagnosis Prediction from EHR Data” [14].
System Maintenance	Frequent downtime during updates; non-modular legacy infrastructure.	Modular microservice architecture enabling seamless updates without full downtime.	“Cloud-Based Frameworks for Efficient EHR Management” [1].

VI. CONCLUSION

This survey highlights that while existing Electronic Health Record (EHR) systems have brought considerable advance- ments to healthcare digitization, they continue to face persis- tent challenges in interoperability, data privacy, scalability, and the integration of intelligent decision-support systems. Many legacy systems operate within isolated environments, limiting efficient data exchange between healthcare institutions and creating bottlenecks in clinical workflows. Additionally, the lack of deep AI integration restricts predictive analytics and diagnostic assistance, resulting in reactive rather than proactive healthcare management.

Our proposed solution, CURA-ID, addresses these lim- itations by introducing a comprehensive, AI-empowered EHR platform that integrates modern technologies such as blockchain for secure data management, federated learning for privacy-preserving analytics, and advanced visualization tools for real-time insights.

By leveraging a modular archi- tecture, CURA-ID ensures flexibility, scalability, and cross- institutional interoperability through standardized APIs and decentralized governance models. The inclusion of patient- centric features such as chatbot assistance, personalized lifestyle recommendations, and recovery prediction models fosters active engagement and shared decision-making be- tween patients and healthcare providers.

Furthermore, the system emphasizes ethical AI use and compliance with evolving healthcare data standards, ensur- ing that data remains both accessible and trustworthy. The integration of predictive heatmaps and intelligent dashboards aids in identifying disease trends, optimizing hospital resource allocation, and supporting data-driven clinical decisions.

In essence, CURA-ID lays the foundation for a next- generation EHR ecosystem—one that is secure, intelligent, interoperable, and patient-driven. This work provides a roadmap for future research and implementation in healthcare informatics, encouraging collaboration between technologists, clinicians, and policymakers to build a transparent, efficient, and human-centered digital health infrastructure.

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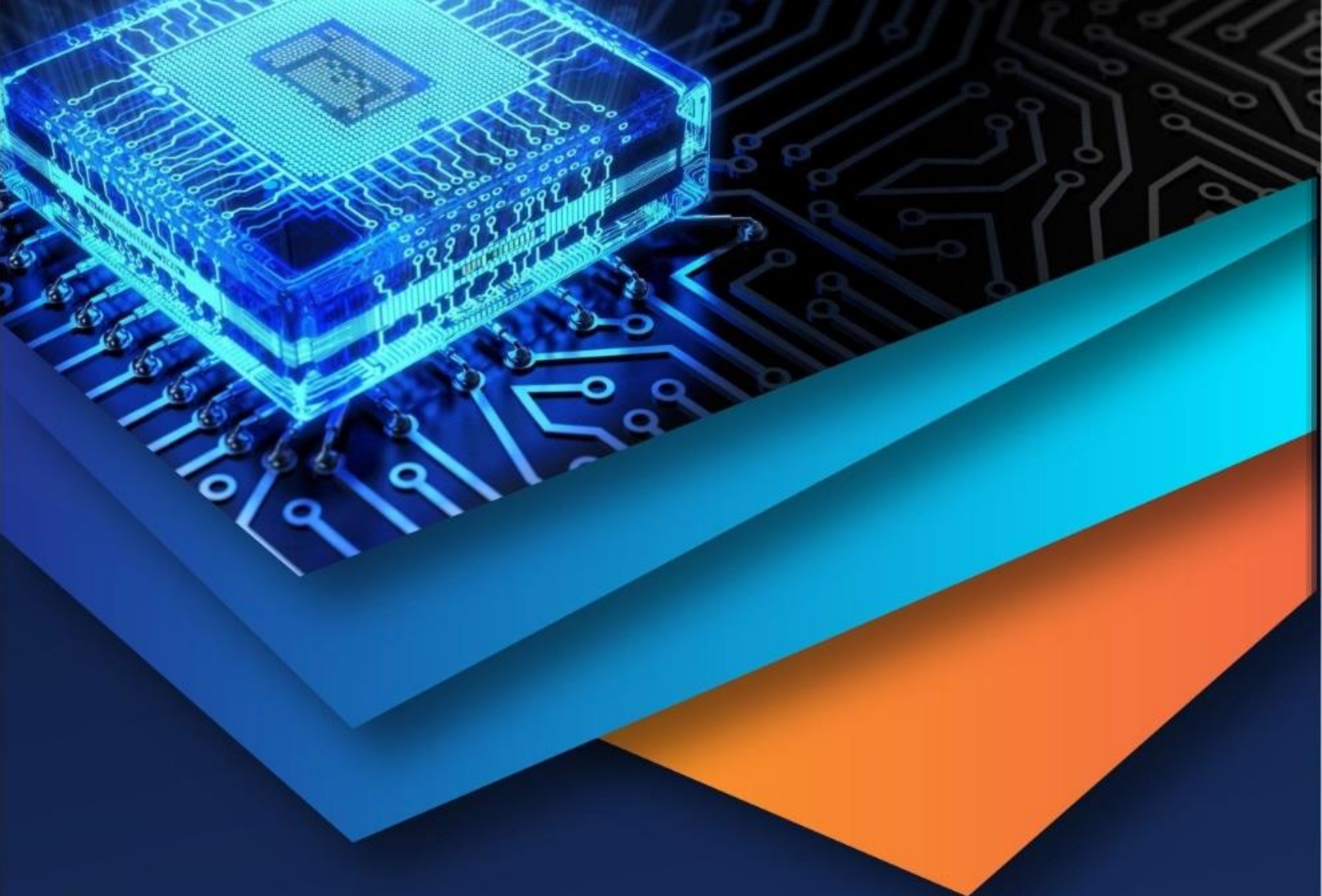

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