Blockchain for Organ Donation: Ensuring Trust, Integrity, and Speed in Transplant Chains

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Abstract— **Organ donation systems face persistent challenges such as lack of transparency, susceptibility to data tampering, and inefficiencies in organ matching and allocation. This paper presents Secure Organ Chain, a blockchain-based framework designed to overcome these issues through decentralized and tamper- proof recordkeeping. By leveraging smart contracts, the system automates the organ donation and allocation process, ensuring fairness and adherence to predefined medical criteria. Cryptographic techniques safeguard the integrity and authenticity of all transactions, protecting sensitive donor and recipient information. Additionally, the integration of electronic health records with the blockchain enhances data accessibility while maintaining privacy and security. Secure Organ Chain fosters trust among stakeholders—including hospitals, transplant centers, donors, and recipients—by ensuring transparency, accountability, and equity throughout the donation process. This innovative approach offers a transformative step toward a more secure, transparent, and efficient organ transplantation ecosystem.**

Keywords: HLA, HLA matching, organ donation, organ matching, blood group matching, Blockchain, HLA Classes A, B and DR, Blood type matching, Overall matching, Hashlib, json, torch, sklearn lable encoder, Django framework, LSTM, ECDSA, Decentralisation, secure, real time.

I. INTRODUCTION

Organ failure, often resulting from chronic diseases or severe injuries, poses a critical public health challenge with life-threatening consequences. Organ transplantation remains one of the most effective life-saving interventions for such patients. However, its success depends heavily on the timely availability of healthy donor organs and accurate donor-recipient matching to minimize medical risks. Since the first successful kidney transplant in 1954 between twin brothers, global transplantation efforts have expanded significantly. Yet, the gap between organ demand and supply remains alarming—approximately 20 individuals die each day awaiting transplants, with a new patient added to the waiting list every 10 minutes. Organ donation occurs through two primary pathways: deceased and living donation. The process begins with a comprehensive donor evaluation conducted by a transplant team. In the case of deceased donors, confirmation of brain death is required, whereas living donors undergo extensive health assessments to ensure medical eligibility. Once cleared, donor records are forwarded to a procurement organization for verification, consent acquisition, and subsequent donor-recipient matching. A ranked list of potential recipients is then generated based on medical compatibility, after which surgeons make the final decision regarding organ acceptance and transplantation.

Historically, donor matching relied on manual processes such as phone calls, often yielding limited successful matches. While modern computerized systems now allow real-time notifications and matching, several critical issues persist—particularly in data security, system transparency, and equitable access. Reports from the World Health Organization estimate that up to 10% of global transplants may involve unethical practices such as organ trafficking, though exact numbers remain uncertain. Furthermore, socioeconomic and geographic disparities continue to affect access to transplantation services, raising concerns about fairness and exploitation. Current organ donation systems also suffer from outdated data security protocols, centralized control, and a lack of standardized communication between hospitals and healthcare authorities, leading to delays and inconsistencies in information exchange.

To address these pressing challenges, blockchain technology has emerged as a promising solution. Its decentralized, tamper-proof ledger system enables

secure, transparent, and immutable data management without reliance on a central authority. Initially developed for cryptocurrencies, blockchain platforms such as Ethereum now support smart contracts—self-executing programs that trigger predefined actions when specific conditions are met. These features make blockchain particularly suitable for organ donation systems, where secure data storage, traceability, and trust are paramount.

This study proposes a blockchain-based framework named Secure Organ Chain, designed to improve the transparency, security, and fairness of organ donation and transplantation management. Built upon the Elliptic Curve Digital Signature Algorithm (ECDSA) and Long Short-Term Memory (LSTM) models, the system offers decentralized data handling to mitigate vulnerabilities associated with centralized databases. Smart contracts automate key processes such as donor-recipient matching and consent verification, while real-time Electronic Health Record (EHR) integration ensures seamless and secure information sharing across healthcare institutions.

The main contributions of this research include the design and implementation of a decentralized blockchain architecture tailored for organ transplantation workflows. Smart contracts are leveraged to register participants, maintain data provenance, and enforce transparency at every stage of the donation process. The contract code is publicly available on GitHub to promote openness and auditability. Furthermore, donor-recipient matching is algorithmically automated using predefined medical parameters, ensuring objective and equitable allocation. The system incorporates six core algorithms, all of which are described, tested, and validated in detail. Rigorous security analysis confirms the framework's resilience against common attacks, and comparative evaluations demonstrate significant improvements over existing centralized solutions.

II. LITERATURE SURVEY

Igboanusi et al., 2024 [1] proposed BOMS, a blockchain- based organ matching system on Ethereum using smart contracts for automated donor-recipient matching with biological compatibility checks. It ensures privacy through anonymized addresses, supports altruistic and directed donations, and offers transparent tracking. Tested across various blockchain types, it achieved a 100% security score.

Damini Mali et al., 2022 [2] proposed OrganTracker, a blockchain and ML-based system for secure, efficient organ donation. It uses Random Forest for compatibility prediction and smart contracts on Ethereum for real-time tracking and tamper-proof storage. The system achieved 80–90% accuracy and reduced allocation time.

Prasoon Soni et al., 2023 [3] developed a blockchain-based organ donation system on Polygon, using smart contracts for identity verification, matching, and tracking. It employs neural networks for compatibility prediction and stores patient data off-chain in MongoDB. The platform ensures transparency, privacy, and tamper-proof records.

Mary Eapen et al., 2011 [4] analyzed 803 cord blood transplants and found that HLA-C mismatches, especially with DRB1, increased mortality and complications. The study emphasizes the importance of including HLA-C in donor matching algorithms, supporting precise matching logic in blockchain-based systems.

Batool Mutar Mahdi, 2013 [5] reviewed the role of HLA typing in transplantation, highlighting its impact on immune response and graft success. It covered typing methods (serology to NGS) and stressed anti-HLA antibody screening. The study supports accurate HLA matching in systems like Secure Organ Chain.

D. Hawashin et al., 2022 [6] proposed a private Ethereum- based system with smart contracts for secure, transparent organ donation and transplant management. It features role- based access, traceable logs, and automated matching using age, blood type, and BMI. Security testing showed strong resistance to vulnerabilities.

Rohit Baba et al., 2024 [7] introduced a blockchain-based organ donation platform on Ethereum to tackle data irregularities and ethical issues. It ensures decentralized medical records, transparent access, and fair allocation via smart contracts, promoting trust and reducing fraud.

Mr. Shrihari et al., 2024 [8] proposed a blockchain-based system to improve transparency, management, and fairness in organ donation. Using smart contracts and distributed ledgers, it ensures secure, traceable, and tamper-proof transactions, enhancing trust and accountability across the process.

Navjeevan Chaudhary et al., 2022 [9] addressed the

organ donor shortage and issues with centralized databases. They proposed a blockchain solution for tamper-proof, verifiable storage of donation records, ensuring data security and transparency.

S. Shanmugam et al., 2024 [10] introduced SecureOrganChain, a blockchain-based framework using Ethereum smart contracts and EHR integration to ensure transparent, tamper-proof organ allocation. It enhances trust and security, promoting equitable transplant management.

III. RESEARCH GAP

Traditional organ donation systems face issues like limited transparency, poor donor-recipient matching, and vulnerability to data tampering due to centralized databases. They lack emergency access, and efficient coordination among stakeholders. Additionally, low public awareness and engagement hinder donor registrations and system effectiveness.

i. Scope of the Study

This study aims to develop a blockchain-based Web DApp that ensures secure, transparent, and efficient management of organ donation processes. The system will utilize decentralized ledger technology to store and track donor and recipient data, ensuring tamper-proof and verifiable records. Key features will include intelligent donor-recipient matching based on critical immunological factors such as HLA-A, HLA-B, and HLA-DR compatibility, along with blood group matching. Emergency data access with consent and a centralized wallet system for secure user authentication will also be provided. An admin dashboard will be integrated for managing hospitals, verifying data, and generating reports. The platform will further enhance public engagement through a user-friendly interface, educational resources, and multilingual support—ultimately improving awareness, trust, and efficiency in organ donation.

IV. PROBLEM STATEMENT

"Organ donation faces challenges like lack of transparency, data tampering, and inefficient matching, leading to critical delays. A secure, transparent system is needed to ensure data integrity, fair allocation, and trust among stakeholders."

V. PROPOSED SYSTEM

The Secure Organ Chain architecture introduces a blockchain-based solution to enhance transparency, security, and efficiency in organ donation and transplantation. Utilizing a private blockchain, it ensures tamper-proof, decentralized data storage accessible only to authorized entities, eliminating dependency on centralized systems and safeguarding data integrity. Smart contracts automate key functions such as donor-recipient matching and consent management, reducing delays while maintaining ethical compliance. Organ compatibility is further strengthened through HLA matching and blood group compatibility, providing greater accuracy and assurance in the matching process. All transactions are immutably recorded, creating an auditable trail, while advanced encryption and role-based access controls ensure data privacy. A web-based interface enables real-time tracking of organ availability and match status, improving coordination across stakeholders. By addressing core issues like data tampering, inefficiency, and lack of transparency, Secure Organ Chain delivers a reliable, secure, and ethically sound framework aligned with evolving healthcare regulations.
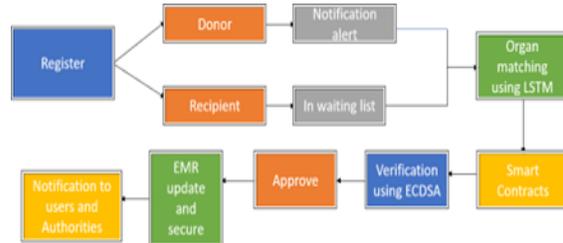
i. Architecture

Figure No.1: Architecture of proposed system

1.Registration:
• Donors and recipients securely submit their personal and medical information on the platform.

2. Notification Alerts:
• Real-time alerts are sent throughout the process to keep all parties informed.

3. Waiting List:
• Recipients are added to a waiting list until a compatible donor is identified.

4. Compatibility Matching:
• HLA matching is performed, focusing on HLA-A, HLA- B, and HLA-DR loci.
• Blood group compatibility is also considered.
• An LSTM-based algorithm analyzes complex

patterns to improve match accuracy.

5. Smart Contract Execution:
• Upon finding a match, smart contracts are triggered to automate and secure key actions.

6. Data Verification:
• The Elliptic Curve Digital Signature Algorithm (ECDSA) is used to verify data authenticity and prevent tampering.

7. Approval Phase:
• Medical and legal approvals are obtained before proceeding.

8. EMR Update:
• The recipient's Electronic Medical Record (EMR) is securely updated, with access restricted to authorized healthcare providers.

9. Final Notifications:
• All stakeholders receive final updates, ensuring real-time visibility and maintaining trust in the process.

VI. METHODOLOGY

This section outlines the process used to build a secure, intelligent organ donation system using Django for web application development, LSTM for donor-recipient compatibility prediction, and blockchain for data integrity. The system emphasizes accurate organ matching, robust verification, and privacy-preserving data handling without real-time organ tracking.

Tech Stack
• Backend: Django (Python), SQLite (Database)
• Frontend: HTML, CSS, JavaScript
• Machine Learning: PyTorch (LSTM model)
• Blockchain Layer: Smart contracts, ECDSA for digital signature verification
• Security: AES encryption, ECDSA verification

1. Data Collection:
Donor and recipient information is collected through secure, web-based forms developed using Django. The fields are limited to essential medical and demographic parameters required for matching and verification.

Collected Fields:
• Name
• Age
• Gender
• Location
• Blood Group
• Organ Type
• HLA Typing
• Disease

The data is stored temporarily in a backend database for preprocessing and analysis.

2. Data Preprocessing
Before prediction, the data undergoes preprocessing to ensure quality and compatibility for the LSTM model.
• Data Cleaning: Removal of null, inconsistent, or duplicate records
• Categorical Encoding: Gender, Blood Group, and Organ Type are encoded for machine learning
• Normalization: Age and HLA scores are scaled
• Location Mapping: Location is processed for distance estimation, if applicable

3. Compatibility Prediction Using LSTM
The core of the system is a Long Short-Term Memory (LSTM) model trained to evaluate the compatibility between donor-recipient pairs. LSTM is chosen due to its ability to handle sequence-based and time-sensitive data, which can model the dynamic nature of organ allocation.

The model considers the following parameters:
• HLA Typing
• Blood Group
• Age and Gender Match
• Location
• Disease compatibility
• Organ Type

It outputs a compatibility score, helping prioritize the best recipient for each available organ.

4. Blockchain Integration with ECDSA Verification
To ensure data integrity and prevent tampering, all critical operations are handled through blockchain smart contracts.
• Smart Contracts: Manage donor-recipient matching and approvals
• ECDSA (Elliptic Curve Digital Signature Algorithm): Verifies the authenticity of data entries and transactions before they are recorded
• Encryption: All sensitive data is encrypted before being submitted to the blockchain
• Access Control: Only authorized hospitals and doctors can interact with the system

5. Organ Allocation and Approval
Once a compatible recipient is identified:

- The system logs the match on the blockchain
- Medical and legal approvals are triggered automatically through smart contracts
- Notifications are sent to relevant users via the Django web interface

6. Web Application Interface

A user-friendly interface is developed using Django, allowing stakeholders to:
- Register and manage donor/recipient profiles
- View compatibility scores and match results
- Monitor allocation progress and approvals
- Access encrypted data securely

7. Security Features
- The system ensures medical data security and compliance with healthcare standards through:
- ECDSA-based Verification: Ensures the authenticity and integrity of every record
- Data Encryption: Protects sensitive fields before blockchain submission
- Immutable Ledger: Every match and update is permanently recorded
- Role-based Access: Limits access to verified users (e.g., hospitals and medical staff)

II.   RESULTS
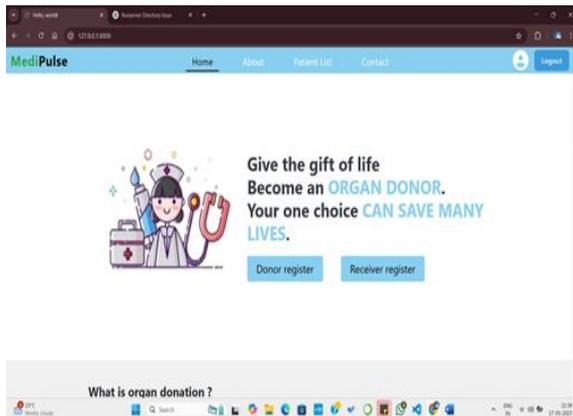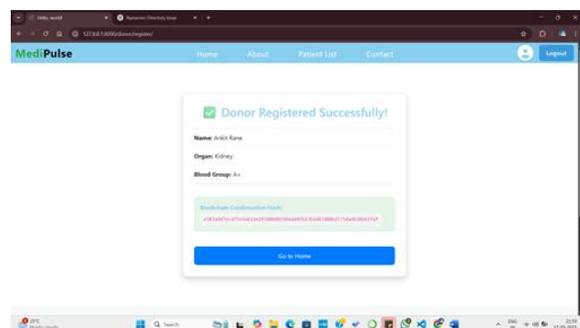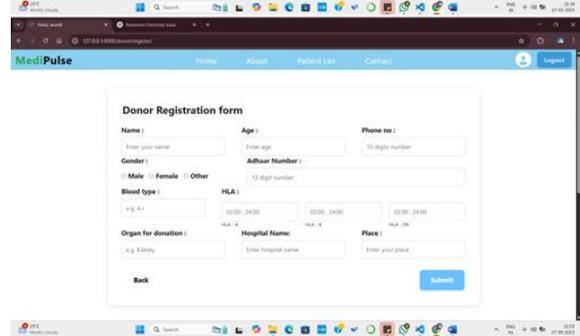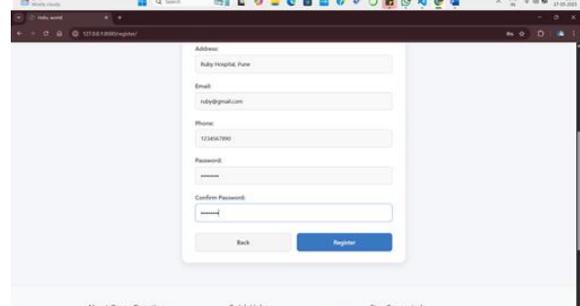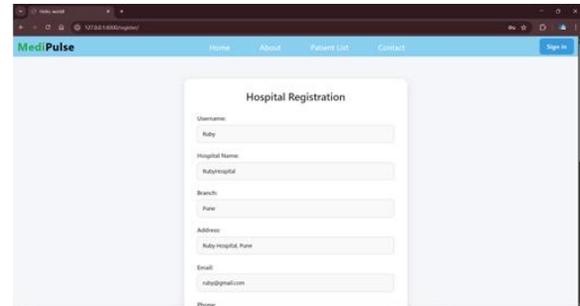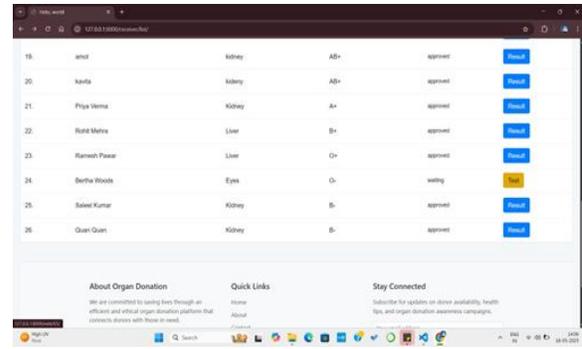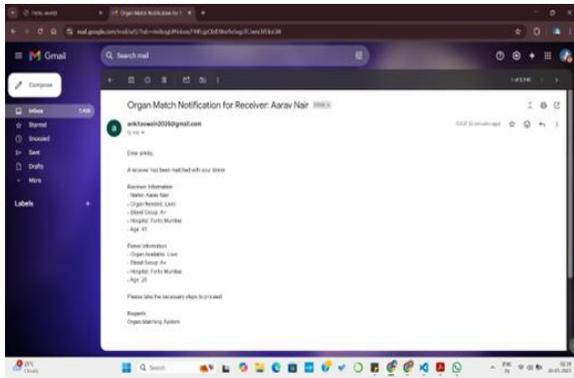
VII. CONCLUSION

The Secure Organ Chain system offers an innovative solution to the major challenges in organ donation and transplantation, particularly concerning security, transparency, and efficiency. By leveraging blockchain technology, the system establishes an immutable, decentralized ledger that ensures all organ donation records are tamper-proof and transparent, enhancing trust and accountability among stakeholders. Smart contracts automate crucial processes such as donor-recipient matching and consent verification, reducing manual intervention and delays. Sensitive data is protected using robust encryption and digital verification techniques like ECDSA, ensuring privacy and integrity throughout the system. This framework directly addresses ethical concerns such as organ trafficking and unfair allocation, promoting a fair and rule-based approach. Its decentralized architecture eliminates reliance on a central authority, further improving security and data integrity. Designed to be scalable and adaptable, Secure Organ Chain aligns with evolving healthcare regulations and technological advancements. By integrating blockchain with intelligent matching mechanisms, it sets a foundation for a more equitable, reliable, and efficient organ donation ecosystem—ultimately saving lives and strengthening public confidence in the healthcare system.

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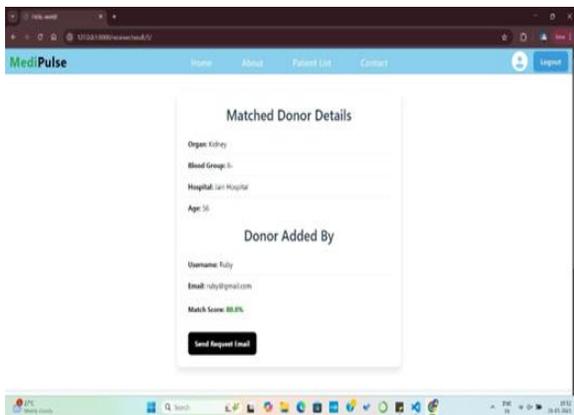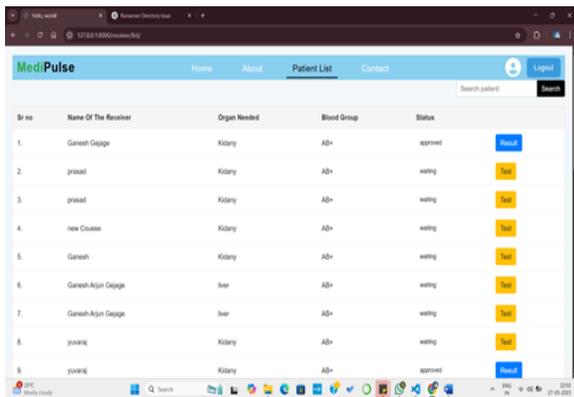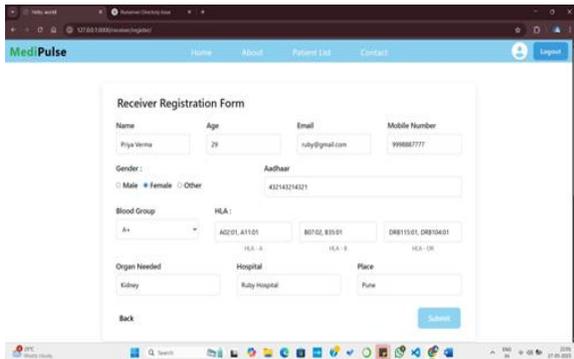
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