ABSTRACT

The modern healthcare infrastructure for organ donation and transplantation faces a wide spectrum of challenges, encompassing both technical and non-technical dimensions. These challenges manifest across various operational stages such as donor registration, matching of donors and recipients, validation of medical eligibility, surgical organ retrieval, transportation logistics, and the final transplantation procedure. Each step is tightly governed by legal regulations, ethical guidelines, medical standards, and data privacy laws. Consequently, the need for a robust, secure, and transparent end-to-end system is paramount to ensure fairness, traceability, and trust throughout the entire process.

Traditional organ transplantation systems are predominantly centralized, relying on governmental bodies or third-party institutions to maintain donor-recipient databases and manage allocation decisions. However, these centralized systems are prone to data manipulation, lack of transparency, systemic bias, operational inefficiencies, and even fraud. Furthermore, patients and their families often feel excluded from the process due to the lack of visibility and real-time access to information, which can erode public confidence and deter participation in organ donation programs.

To address these critical shortcomings, we introduce a blockchain-based decentralized solution built on a private Ethereum network. Blockchain, by design, offers immutability, distributed consensus, and transparent ledger capabilities—features that are ideally suited for managing sensitive and high-stakes processes like organ donation and transplantation.

Our system leverages smart contracts—autonomous scripts deployed on the Ethereum blockchain—to automate key operations such as:

- Donor registration and verification, with cryptographic security.
- Real-time donor-recipient matching, based on medical criteria, urgency, and geographical proximity.
- Consent management, ensuring that the donor’s and family's intentions are honoured.
- Organ transport tracking, with tamper-proof audit logs.
- Automated alerts and validations, to reduce manual errors and delays.

We also designed and implemented six specialized algorithms that govern different functional modules of the system. These include matching algorithms optimized for multi-factor compatibility, validation routines for clinical eligibility, transaction verification, route optimization for organ delivery, and more. Each algorithm was rigorously developed, tested, and validated through simulation scenarios and stress tests to ensure their effectiveness in real-world conditions.

To evaluate the robustness and practicality of the proposed system, we performed a thorough analysis covering security, privacy, and confidentiality. The system adheres to major compliance standards such as GDPR and HIPAA, protecting sensitive health data while allowing traceability and accountability. Additionally, our solution was benchmarked against existing centralized platforms, showing significant improvements in transparency, processing time, and resistance to manipulation or single points of failure.

In the spirit of open-source collaboration and academic contribution, we have made our complete smart contract codebase and implementation details available on GitHub. This allows researchers, developers, and public health organizations to review, adopt, and enhance the system for broader use, potentially scaling it across regions or integrating it with national health services.

Ultimately, this project demonstrates how blockchain technology can revolutionize the organ donation landscape, offering a future-ready solution that is fair, efficient, and worthy of the trust that such life-critical processes demand.

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