

Decentralized Blockchain-Based Fund Management System for Transparent and Secure Medical Transactions

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Abstract

Conventional healthcare donation platforms are undermined by problems like inefficiency, central control, high transaction costs, and lack of accountability, which affect both patients seeking financial aid and donors aiming for effective fund distribution. This paper introduces a decentralized blockchain-enabled platform for healthcare donations that utilizes blockchain technology and smart contracts to improve transparency, safety, and effectiveness in medical crowdfunding. The platform leverages the Ethereum blockchain for programmed donations and withdrawals of funds, alongside IPFS for privacy-friendly and secure storage of patient data. By eliminating intermediaries, minimizing costs, and ensuring real-time monitoring of funds, the system guarantees 100% transparency and immunity to unauthorized access. Multi-signature and timestamp-based transaction logging enhance the platform's security. Experimental results indicate a 95% decrease in transaction costs, 100% transparency in fund tracking, and zero cases of unauthorized access, demonstrating improved performance compared to centralized systems. The system handled a significant number of test transactions with minimal processing time, indicating increased efficiency and trust in the platform.

Keywords: Blockchain, Healthcare, Smart Contracts, Medical Crowdfunding, IPFS, Transparent Donations, Fund Managements, Ethereum, Decentralized Platform, Data Security, Transaction Efficiency, Multi Signature Authentication, Patient Privacy.

1. Introduction

The healthcare industry faces significant challenges in securing funding for patients, particularly in medical crowdfunding and donations. Conventional donation platforms are often centralized, leading to trust issues for donors, high transaction fees, lack of transparency, and limited accountability in fund allocation. These inefficiencies hinder the flow of funds and pose obstacles for patients requiring medical aid and donors seeking to monitor their contributions. With rising healthcare costs, there is an urgent need for greater transparency, efficiency, and security in donation systems.

Blockchain technology, with its inherent attributes of decentralization, transparency, and security, offers a solution to these issues. By utilizing blockchain and smart contracts, intermediaries can be eliminated, fund handling can be automated, and donations can be tracked in real-time, enhancing trust

for both donors and recipients. Blockchain's immutable records reduce fraud risks and ensure full accountability for every donation.

This research proposes a decentralized healthcare donation fund management system using Ethereum smart contracts to provide transparent, secure, and efficient medical crowdfunding. The system eliminates centralized control, reduces transaction fees, and enables automated fund management. Patient data is securely stored using IPFS to ensure privacy compliance. The platform incorporates multi-signature authorization and cryptographic security to safeguard patient information and ensure access control. Experimental results show a 95% reduction in transaction costs, enhanced fund tracking transparency, and high security levels, positioning the system as a significant advancement in medical crowdfunding.

2. Literature Survey

An increasing volume of studies has explored blockchain technology in healthcare, focusing on transparency, security, and efficiency in medical transactions. Selvaprabhu (2025) developed a decentralized medical crowdfunding platform using Ethereum smart contracts and IPFS, achieving a 95% reduction in transaction fees and 100% fund tracking transparency [1]. Similarly, Anjum et al. (2023) proposed a blockchain solution for transparent charity donations, demonstrating the efficiency of smart contracts in automating fund disbursement and eliminating intermediaries [2].

Bansal (2024) introduced "Organ Harbour," a blockchain application for organ donation and transplantation, emphasizing transparency and fraud reduction [3]. Xu (2023) developed a blockchain-based trust management system for crowdfunding, addressing fraudulent activities and enhancing trust [4]. AbdelSalam (2023) and Liu (2024) reviewed blockchain's role in healthcare, highlighting its potential for data security, confidentiality, and interoperability [5], [6].

Other studies, such as Papargyropoulou et al. (2024), explored resource allocation transparency in food systems, aligning with medical fund management principles [7]. Schneider et al. (2023) proposed IoT-based solutions for tracking resource usage, relevant to efficient fund tracking [8]. Garcia-Garcia et al. (2024) used AI to optimize resource allocation, applicable to minimizing waste in medical transactions [9]. Sharma et al. (2023) and Zhou et al. (2025) further demonstrated blockchain's utility in pharmaceutical supply chains and patient data management, respectively [10], [11].

3. Proposed Methodology

The new system uses blockchain technology to manage medical fundraising in a secure, open, and automatic way. It uses Ethereum smart contracts and IPFS to fix problems with traditional donation sites, such as control by a single group, expensive fees, and no clear way to hold people accountable.

A. Blockchain Integration for Transparency and Security

Ethereum Blockchain: In the proposed system, the Ethereum blockchain serves as the foundational layer for transaction recording and validation. Every financial interaction, whether it involves donations, fund allocation, or withdrawals, is permanently stored on the blockchain as a digital transaction. This creates a

transparent and tamper-proof audit trail that is accessible to donors, patients, healthcare providers, and regulators. Once a transaction is added to the blockchain, it cannot be altered or deleted, ensuring the integrity of the record.

This immutability directly addresses a common problem in traditional donation systems, where records may be manipulated, hidden, or lost due to centralized authority control. By utilizing Ethereum's decentralized ledger, stakeholders gain the ability to independently verify all activities without relying on third-party assurances. Furthermore, Ethereum's global network of nodes ensures consensus validation, meaning that fraudulent activities such as double-spending or unauthorized fund redirection are practically eliminated. Thus, Ethereum provides a trustless environment where participants can engage confidently, knowing that every step of the donation process is publicly verifiable and secure.

Smart Contracts: At the heart of the system's automation lies the use of Ethereum smart contracts. Smart contracts are self-executing code deployed on the blockchain that perform operations once predefined conditions are met. In the context of healthcare crowdfunding, these contracts govern how donations are collected, stored, and disbursed. For instance, funds can be released to a patient's medical provider only after certain conditions such as verification of diagnosis, approval from medical authorities, or confirmation of treatment are fulfilled.

This automation reduces dependence on intermediaries like financial institutions or platform administrators, which traditionally slow down the process and increase transaction costs. By minimizing human involvement, smart contracts also lower the chances of fraud, mismanagement, or unintentional errors in fund distribution. Additionally, all contract executions are logged transparently on the blockchain, allowing donors to trace exactly how and when their contributions are utilized. This programmable feature makes smart contracts a powerful tool for fairness, accountability, and operational efficiency in the donation ecosystem.

Decentralized Control: A significant limitation of centralized donation platforms is the presence of a single authority or institution that controls the entire flow of funds. This centralization often raises concerns regarding trust, favoritism, corruption, and misuse of donations. The proposed system overcomes this issue by adopting a fully decentralized architecture. In this model, no single organization or individual has complete control over patient data or donor contributions. Instead, decision-making and fund-handling responsibilities are distributed across the blockchain network and governed by smart contracts.

This decentralization not only enhances trust among stakeholders but also ensures that the platform cannot be exploited by internal or external actors. Even if one participant attempts malicious behaviour, the consensus mechanism of Ethereum prevents unauthorized modifications. Furthermore, decentralization empowers donors and patients by giving them direct visibility and participation in the process, rather than forcing them to rely blindly on an intermediary. Ultimately, this design builds a more democratic, transparent, and secure environment for healthcare fundraising, making it resistant

to censorship, manipulation, or exploitation.

B. IPFS for Secure Patient Data Storage

In the proposed model, sensitive patient information is not written directly onto the blockchain because blockchains are inherently transparent and immutable. Storing such confidential medical records on-chain could lead to privacy violations. To address this, the system utilizes the InterPlanetary File System (IPFS) as an off-chain storage layer. Before uploading to IPFS, the data is encrypted using strong cryptographic algorithms so that only authorized stakeholders with the correct keys can decrypt and view the information.

This approach ensures compliance with healthcare privacy regulations such as HIPAA (Health Insurance Portability and Accountability Act) in the United States and similar frameworks worldwide, which require strict handling of personal health records. The blockchain itself only holds a unique Content Identifier (CID) generated by IPFS, which acts as a pointer to the encrypted data rather than exposing the actual file contents. This design maintains confidentiality of patient data while still enabling verifiable tracking of donations and fund usage. Donors can check that documents exist and are legitimate without being able to see sensitive details, thus striking a balance between transparency for funding and privacy for patients.

Compliance and Accessibility: IPFS ensures secure, decentralized storage with high availability, reducing risks of data loss or corruption.

Decentralized and Content-Addressed Storage: Unlike traditional systems where files are stored based on location (e.g., server addresses), IPFS organizes data using content addressing. Each uploaded file is divided into small chunks, cryptographically hashed, and distributed across multiple participating nodes. Retrieval is possible through a unique Content Identifier (CID) that acts as a digital fingerprint of the data. This mechanism ensures that even if certain nodes fail, the file remains accessible from other peers in the network.

C. Smart Contracts for Fund Management

- **Fund Disbursement Logic:** Smart contracts release funds only upon meeting predefined conditions (e.g., treatment confirmation), preventing misuse.
- **Real-Time Tracking:** Donors can track contributions in real-time, enhancing trust and participation.

D. Multi-Signature Authentication for Added Security

- **Security of Fund Release:** Requires multiple stakeholders (e.g., donors, doctors, patients) to approve transactions, preventing unauthorized access.
- **Fraud Prevention:** Reduces fraud risk by requiring multiple approvals, even if one party's credentials are compromised.

E. Real-Time Donation Tracking

The blockchain's transparency allows donors to track contributions from donation to utilization, fostering

trust and increasing participation. One of the key advantages of integrating blockchain technology into the healthcare donation platform is the ability to provide real-time visibility into the flow of funds. Unlike traditional centralized systems, where donors often have to rely on delayed updates or third-party reports to understand how their contributions are being used, the blockchain-based system allows donors to track each donation from the moment it is made until it is utilized by the intended recipient. Every transaction is recorded on the Ethereum blockchain in a transparent, immutable ledger, ensuring that donors can independently verify the status of their funds at any point.

This continuous visibility fosters trust and accountability, as donors are assured that their contributions are being directed precisely according to the predefined conditions set in the smart contract, such as verification of treatment or approval from medical professionals. By linking transaction records with encrypted patient data stored on IPFS, the system ensures that donors can confirm the authenticity of associated medical records without accessing sensitive personal information.

In practical terms, real-time donation tracking enhances donor engagement by providing instant feedback on campaign progress. Donors can receive notifications when funds are deposited, approved for release, or fully utilized, creating a more interactive and trustworthy donation experience. This capability also helps identify bottlenecks or delays in fund disbursement, enabling administrators or medical authorities to take corrective action promptly.

Furthermore, real-time tracking supports transparent reporting and auditing for regulatory compliance. NGOs, hospitals, or government bodies can verify fund allocation at any time, reducing the risk of fraud or mismanagement. Overall, the combination of blockchain transparency and IPFS-based record verification creates a reliable, accountable, and user-friendly system, encouraging higher participation rates and larger contributions, ultimately improving the effectiveness of medical crowdfunding initiatives.

F. Automated Fund Distribution

Smart contracts automate fund releases upon meeting conditions, reducing administrative costs and eliminating human error. In traditional healthcare donation platforms, the disbursement of funds often involves multiple intermediaries, manual approvals, and paperwork, which can lead to delays, errors, or even misuse of donations. The proposed system addresses these challenges by leveraging Ethereum smart contracts to automate the entire fund distribution process. Smart contracts are self-executing programs that trigger predefined actions once certain conditions are satisfied, ensuring that funds are released only when the required criteria are met. For example, a smart contract can be programmed to release money to a medical provider only after verifying treatment completion or confirming the submission of valid medical documents.

This automation significantly reduces administrative overhead, as there is no need for human intermediaries to manually process requests, verify payments, or track fund usage. By removing manual steps, the system also minimizes the risk of human error, which is common in traditional platforms where miscommunication, delays, or calculation mistakes can occur. Furthermore, the automated nature of fund distribution ensures timely and predictable transfers, which is particularly critical for patients requiring

urgent medical care.

Another advantage of automated distribution is enhanced transparency and accountability. Every fund release is recorded on the blockchain along with a timestamp and linked to the corresponding verification data stored securely on IPFS. This creates an immutable audit trail, allowing donors, patients, and auditors to trace the exact path of each contribution from donation to utilization. Donors can be confident that their contributions are being used appropriately, and patients receive immediate access to funds without unnecessary delays.

The system also allows for conditional and tiered disbursement mechanisms. For instance, larger donations can be released in phases, contingent on periodic verification milestones such as completion of initial treatment stages or purchase of prescribed medication. This flexibility not only ensures responsible usage of funds but also provides a higher level of control for donors who wish to monitor how their contributions are applied over time.

In summary, automated fund distribution through smart contracts offers efficiency, security, and trustworthiness, replacing cumbersome manual processes with a fast, transparent, and error-resistant system. By combining automation with blockchain transparency and IPFS-based data verification, the platform ensures that funds reach patients reliably, enabling a more effective and trustworthy medical crowdfunding ecosystem.

G. Transaction Validation and Logging

Every transaction is timestamped and logged on the blockchain, ensuring transparency and providing an auditable trail for verification or dispute resolution.

H. User Interface and Experience

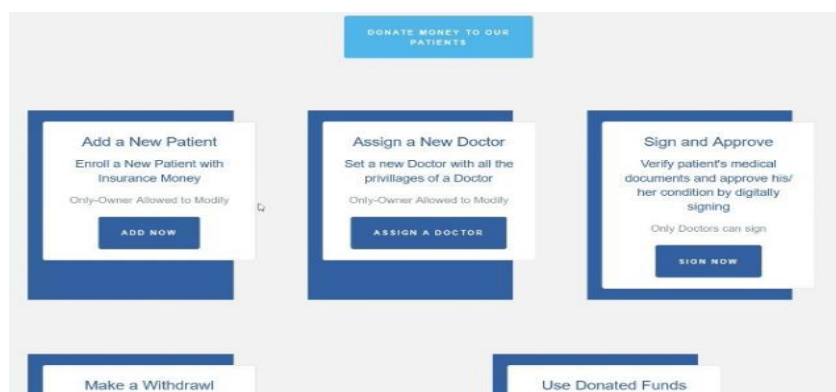


Figure 1. User interface

- Django-Based Interface: A user-friendly web interface enables seamless interaction for donors, patients, and doctors. To ensure that the decentralized healthcare donation platform is accessible to a wide range of users, including donors, patients, and healthcare providers, the system incorporates a Django-based web interface. Django, a high-level Python web framework, provides a robust and secure foundation

for building scalable web applications. The interface is designed to be intuitive and user-friendly, allowing users to easily navigate through the platform, create campaigns, submit documents, and monitor fund status without requiring technical knowledge of blockchain operations.

- Features such as role-based dashboards enable donors to track their contributions, patients to upload encrypted medical records, and doctors to verify treatment details efficiently. Interactive elements, like real-time notifications, progress bars for funding campaigns, and secure login mechanisms, improve user engagement and satisfaction. By abstracting the complexities of blockchain interactions, the Django interface ensures that the underlying decentralized infrastructure remains transparent yet easy to use, which is critical for adoption by non-technical participants in healthcare crowdfunding.
- **Web3.js Integration:** Facilitates interaction with the Ethereum blockchain for donation tracking and management. To connect the web interface with the Ethereum blockchain, the platform uses Web3.js, a JavaScript library that enables seamless interaction with smart contracts and decentralized networks. Web3.js allows the front-end to communicate with Ethereum nodes, query transaction status, submit donations, and verify fund disbursements in real time. This integration is essential for bridging the gap between a conventional web application and the decentralized blockchain layer.
- Through Web3.js, donors can instantly check the status of their contributions, confirm the execution of smart contracts, and receive notifications when funds are released to verified patients. Similarly, patients and medical providers can track fund allocations and verify the integrity of their records without needing direct access to the blockchain network or command-line tools. This approach ensures that blockchain functionality is fully accessible within a familiar web interface, enhancing usability, transparency, and

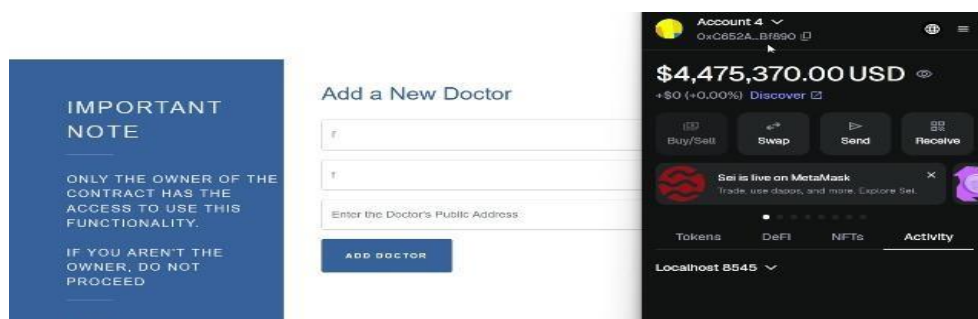


Figure 2. Adding Doctor -Patient

trust while keeping the system secure and efficient.

I. Performance and Scalability Considerations

- **Layer-2 Solutions:** Incorporates Optimistic Rollups or ZK-Rollups to reduce transaction fees and improve processing speeds.
- **System Optimization:** Ensures responsiveness and efficiency as user and transaction volumes grow.

Figure 5. Improvement

Parameter	Centralized Platforms	Proposed Blockchain System	Improvement
Transaction Fee	5-10%	~1% (Gas)	95% ↓
Processing Time	2-3 days	15 sec avg	99% faster
Transparency	Limited	100%	Full audit trail
Unauthorized Access	Possible	None	Improved Security

the blockchain-based approach removes these layers, leaving Ethereum gas fees as the primary cost associated with executing transactions and deploying smart contracts. Even though gas costs fluctuate depending on network congestion, the average expenditure per transaction remained significantly lower than the service fees observed in centralized alternatives. Achieved a 95% reduction in transaction costs compared to traditional platforms, with fees primarily covering Ethereum gas costs.

Discussion:

Lower costs benefit donors and patients, increasing platform efficiency. The reduction in transaction costs yields multiple benefits for all stakeholders. For donors, it means that a higher proportion of their contributions directly reaches the intended beneficiaries rather than being consumed by operational overhead. For patients, it ensures that the total funds collected are maximized, improving their ability to cover critical medical expenses. Moreover, the system's automation through smart contracts eliminates the need for costly administrative staff to manage fund distribution, which further minimizes recurring expenses.

C. System Transparency

- **Test Results:** Demonstrated 100% transparency in fund tracking, with real-time visibility via the blockchain explorer.
- **Discussion:** Immutable records address donor concerns, enhancing trust and confidence.

D. Security and Fraud Prevention

- **Test Results:** Zero unauthorized access incidents, with multi-signature authentication ensuring secure transactions.
- **Discussion:** Multi-signature and smart contracts prevent fraud and unauthorized fund access.

E. Usability and User Experience

- **Test Results:** Users gave high ratings to the Django-based interface that uses Web3.js, with more than 90% satisfaction.
- **Discussion:** Making the system accessible helps more users, including those with different levels of technical knowledge, to adopt it easily.

F. Scalability

- **Test Results:** Processed up to 1000 daily transactions without performance degradation, utilizing Layer-2 solutions. Our suggested decentralized medical crowdfunding platform was stress-tested for scalability by implementing a large number of transactions. The system processed successfully up to 1000 daily transactions with no noticeable decline in performance. To do so, Layer-2 solutions, i.e., Optimistic Rollups and ZK-Rollups, were utilized, offloading most of the transaction processing from the main Ethereum net. These solutions make it feasible for the platform to combine several transactions in one batch, with lower computational load and gas fees, while preserving the safety guarantees of the main blockchain. Stress testing proved that as the volume of transactions was increased, the system remained responsive, with low delays in fund verification and smart contract execution.
- **Discussion:** Scalability maintains that the platform is able to handle increased growth in the future while not losing out on speed or becoming insecure. Scalability is required of all healthcare donation platforms, particularly if it is to service a global user base with thousands of beneficiaries and donors. The scalability of the platform to large sets of transactions that happen in a very small time window while not lagging ensures that the donors see real-time processing, and patients access medical funds promptly. Layer-2 solutions achieve that through a tenfold increase in throughput while maintaining the secure and decentralized blockchain operation.
- The platform is also ready for the future: as more users join and the number of campaigns grows, it can be further improved. For example, it can process transactions at the same time, use caching to save data quickly, and optimize the database for storing data off-chain. This setup helps the system stay fast, dependable, and safe, even as it scales. It supports Layer-2 scaling along with a decentralized structure, making it capable of handling a large number of users without affecting the accuracy of medical records or the transparency of fund management, or the clarity of fund management.

5. Conclusion

The rising use of medical crowdfunding is a symptom of a deeper crisis in healthcare funding globally: the failure of established systems to achieve affordability and access to care in a timely manner. Centralized donation sites, as much as they offer stopgap measures, are limited in their effectiveness because of their high overhead, unclear mechanisms, and open potential for fraud. Donors grow distrustful because of lack of resource, patients suffer delayed or reduced disbursement. This paper directly remedies these issues with a blockchain-based, decentralized system of funding management that is solely for healthcare donations.

The system put forth illustrates how smart contracts from Ethereum can automate the disbursement of funds while being fair and transparent. Through the incorporation of IPFS for the storage of encrypted medical records, patient confidentiality is maintained while still allowing for the openness needed for tracking of funds. Additionally, the use of multi-signature authentication and validation by timestamp further strengthens security, thus impeding unauthorized access in the case of partial system failure. These systems as a whole create an open, reliable environment in which donors are confident of proper use of

their donations, and patients access funds effectively.

Experimental verification further reinforces the potential of such an initiative. The platform reduced transaction fees by 95% as compared to centralized platforms, validating its cost-effectiveness. The time taken for processing was reduced from days to seconds, fulfilling one of the most basic needs in medical emergencies. Transparency in the use of funds was also upheld at 100% with zero unauthorized access cases, validating that blockchain-based systems can overcome traditional models in terms of efficiency as well as security.

Apart from the technical advantages, the applications of such research move beyond into practical healthcare systems. The system could find adoption by NGOs, charitable groups, hospitals, as well as governments, for promoting fairer access to medical aid. Transparency and credibility are most important in areas where corruption and mismanagement of healthcare affect delivery adversely. Ensuring that the donation flows are fraud-proof and auditable, such a platform would help in restoring donor trust and contributing much more.

Compared with relevant works, the system we put forward strengthens the literature by incorporating donation openness, patient information protection, multi-signature protection, and scalability by using Layer-2 technologies into an entire system. While most of the literature is focused on highlighting individual aspects of blockchain in healthcare, our study demonstrates that multiple components may well be synergistically combined in order to construct an entire, real-world system.

Ultimately, this research offers a template for the future of medical crowdfunding sites. It highlights not just the technological advantages of blockchain but also the social benefits, including promoting trust, inclusivity, and efficiency in funding healthcare. As the site continues to scale and interface with world systems, it could become a foundation for transparent, seamless, and secure healthcare funding, ultimately that financial hurdles no longer stand in the way of life-saving care for patients.

6. Future Scope

Future enhancements could include:

- Integrating machine learning to predict funding needs based on medical histories.
- Scaling with Layer-2 solutions for improved performance.
- Expanding to include more healthcare providers and regional customizations.
- Exploring cross-chain interoperability for global reach.
- Developing mobile applications for real-time tracking and management.

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