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Leveraging Public Blockchain for Secure and Transparent Medical Data Sharing in Pandemics

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ABSTRACT: The COVID-19 pandemic highlighted the critical need for accurate healthcare data reporting and sharing, emphasizing the importance of reliable systems for the exchange of test results and vaccination information between nations. While blockchain and cryptographic technologies have been increasingly explored to address these challenges, many existing systems still face limitations in areas such as user authorization, data privacy, speed, and scalability. Most solutions rely on private or consortium blockchains, which, though secure, do not provide the transparency of public blockchains. This study proposes a novel solution using public blockchain technology, specifically Ethereum, combined with smart contracts, decentralized storage through IPFS, and fast encryption methods such as ChaCha20. The proposed system overcomes the shortcomings of previous approaches by storing encrypted keys alongside encrypted data, enhancing both security and scalability. Additionally, it empowers patients by giving them full control over their medical data, allowing them to manage access permissions without the need for private keys from medical professionals. The use of smart contracts ensures that only authorized users can access sensitive information. This framework presents a fast, scalable, and privacy-centric solution for managing and sharing healthcare data, providing an innovative approach to the secure handling of medical records during pandemics like COVID-19.

I. INTRODUCTION

The rapid spread of infectious diseases during pandemics underscores the need for efficient, reliable, and transparent sharing of medical data among healthcare providers, governments, and global health organizations. Traditional centralized systems often face challenges such as data silos, delayed reporting, lack of interoperability, and vulnerability to cyberattacks. These weaknesses can severely hinder pandemic response efforts, leading to misinformed decisions and delayed interventions. Public blockchain technology emerges as a transformative solution to these issues. As a decentralized, distributed ledger, blockchain ensures that medical data—such as test results, vaccination records, and hospital capacity can be securely shared in real time while maintaining transparency and data integrity. Each transaction or data entry is cryptographically verified and permanently recorded, making tampering nearly impossible. Furthermore, public blockchains promote trust among stakeholders by eliminating the need for intermediaries. Smart contracts can automate data access permissions and enforce compliance with privacy regulations such as HIPAA or GDPR. This enables a balance between data transparency and patient confidentiality, especially vital during emergency health responses. By leveraging public blockchain, healthcare ecosystems can improve coordination, enhance public trust, and respond more effectively to current and future pandemics.

II. LITERATURE SURVEY

Title: Blockchain technology in a crisis: Advantages, challenges, and lessons learned for enhancing food supply chains during the COVID-19 pandemic.
Author: M. W. Akram, N. Akram, F. Shahzad, K. U. Rehman, and S. Andleeb.
Year: 2024.
Description: This study investigates how blockchain technology was utilized in China's food supply chain during the COVID-19 outbreak. It follows an interpretive research approach and collects feedback from key players like vegetable vendors, online platforms, meat and dairy industries, and retail stores. The research highlights blockchain's strengths in improving traceability, reliability, transparency, and operational efficiency. Despite its potential, the study also points out practical challenges such as workforce data handling, interoperability issues, financial constraints, data accuracy, and regulatory barriers. The authors present a strategic approach to tackle these issues, emphasizing collaboration,

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standardization, and stakeholder engagement. Their findings offer actionable suggestions like targeted support for farmers, better risk management, and sustainable agricultural investments, ultimately proposing blockchain as a key tool for building a more robust and secure food supply system during crises.

Title: A scalable blockchain based framework for efficient IoT data management using lightweight consensus.
Author: E. U. Haque, A. Shah, J. Iqbal, S. S. Ullah, R. Alroobaea, and S. Hussain.
Year: 2024.
Description: This research introduces a blockchain-based solution aimed at addressing the performance bottlenecks in managing massive IoT networks. Traditional blockchain methods often struggle with the volume and speed of IoT data. To overcome this, the authors propose a scalable architecture using Delegated Proof of Stake (DPoS), a more efficient and lightweight consensus algorithm. The framework leverages IPFS for decentralized file storage and Docker for testing performance metrics such as throughput, latency, and resource usage. Results show a significant improvement in network performance, with latency kept under 0.976 milliseconds—surpassing traditional PoS models. The study demonstrates that this model is especially effective for IoT environments that require fast, secure, and efficient data handling.

Title: A blockchain-based privacy-preserving healthcare data sharing scheme for incremental updates
Author: L. Wang, X. Liu, W. Shao, C. Guan, Q. Huang, S. Xu, and S. Zhang
Year: 2024.
Description: In the context of AI-driven advancements in healthcare, data sharing is crucial but often hindered by privacy concerns and unclear data ownership. This paper presents a blockchain and Trusted Execution Environment (TEE)-based approach that allows secure, privacy-focused sharing of healthcare data while supporting incremental updates. The solution avoids frequent on-chain modifications, instead using chameleon hashing and symmetric encryption for secure off-chain storage. Data decryption and verification processes occur within the TEE to ensure protection. The method is designed to address the inefficiencies of traditional blockchain data updates and demonstrates strong performance in trials. The proposed system enables efficient, secure data sharing that is vital for the future of personalized and AI-enhanced healthcare.

III. METHODOLOGY

EXISTING SYSTEM

During COVID-19, the urgent need for reliable and fast medical data exchange became evident. Traditionally, hospitals have maintained control over patient records for decades. Transferring these records can take days and is often complicated, especially across institutions in different regions. While research into using blockchain in healthcare has gained momentum, many existing solutions still fall short. They struggle with empowering users to manage their data, ensuring personal data security, and addressing issues like scalability and system speed.

EXISTING SYSTEM DISADVANTAGES

- High risk of data breaches.
- Inability to share records securely and efficiently.
- Delays in obtaining patient records from hospitals, often spanning several days.

PROPOSED SYSTEM

Pandemic-related medical data, such as COVID-19 information, tends to be smaller and easier to store. This makes it a good fit for blockchain-based systems with acceptable delays. The proposed solution introduces a decentralized framework built on a public blockchain (like Ethereum), enhanced with smart contracts, and backed by IPFS for secure file storage. Encryption protocols like ChaCha20 and AES are used to safeguard data. The system offers enhanced privacy, faster access, and better data control, especially during health crises.

PROPOSED SYSTEM ADVANTAGES

- Patients can register in the system and have complete authority over their medical data uploaded by hospitals.
- Uses fast and proven cryptographic algorithms for optimal security.
- Patients can grant or revoke access to their records at any time, retaining full ownership.

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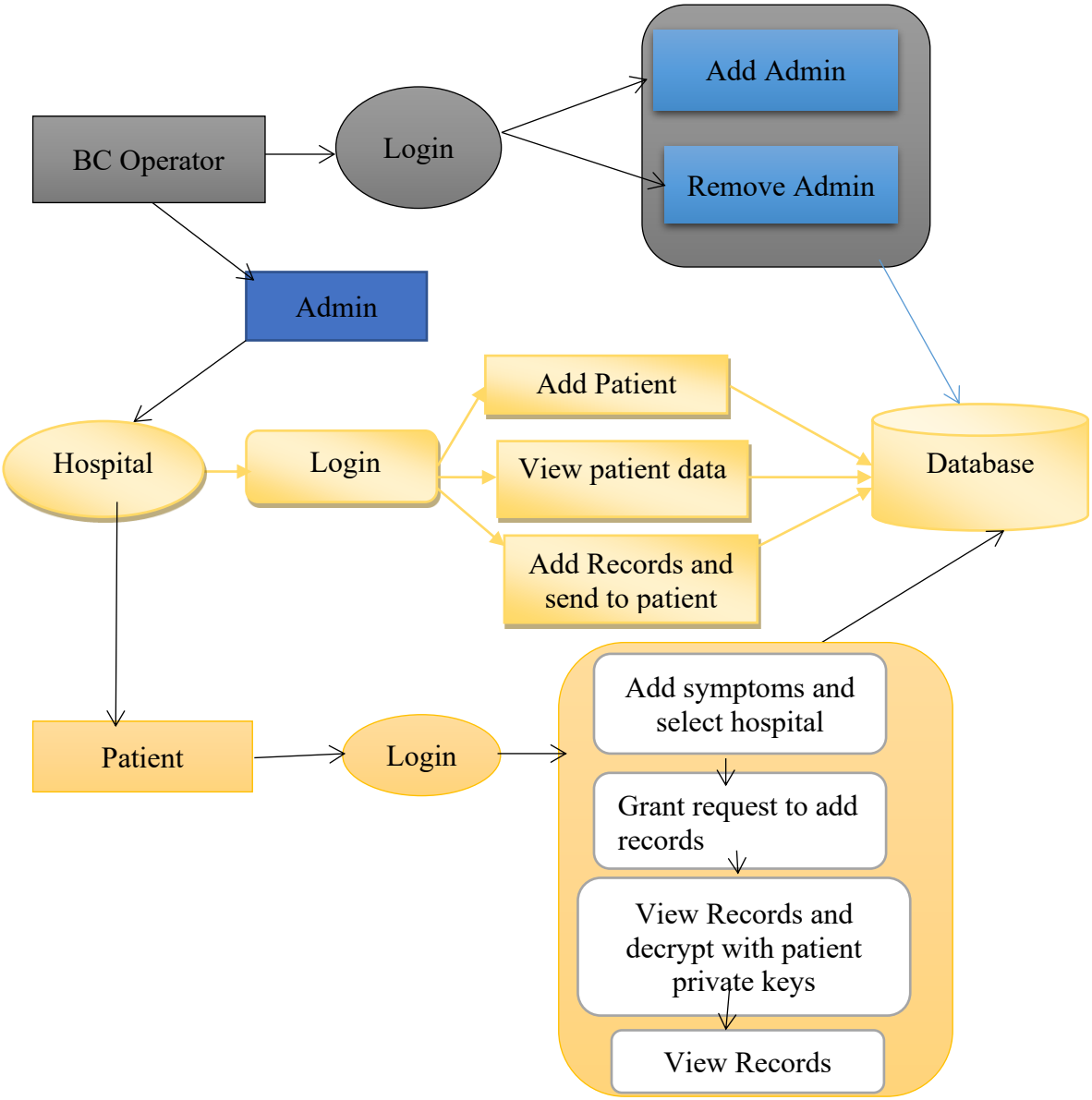
SYSTEM ARCHITECTURE



MODULES:

1. USER INTERFACE DESIGN

The user interface is the first point of interaction for anyone using the system. New users must register by providing their details like username, password, email, city, and country. Once registered, log in with their credentials. The system verifies these details and grants access accordingly. If the login details are invalid, an error is displayed, and the user is redirected to register. Upon successful login, users can search queries and view related information.

2. BC OPERATOR

The BC Operator acts as the system's moderator. This module enables the operator to log in and manage administrative access by adding or removing admins. It forms the backbone of administrative control in the system.

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3. ADMIN

Admins are created by the BC Operator. Once an admin logs in with valid credentials, they are directed to their home dashboard. Their primary responsibility is to add new hospitals to the system and oversee hospital-related data and actions.

4. HOSPITAL

Hospitals log in with their credentials and access a dashboard where they can manage patients. They can add patients, request access to patient records, and update information such as vaccinations or health precautions. The system generates a smart contract using blockchain when a patient is admitted, ensuring transparency and security in record handling.

5. PATIENT

Patients log in using their name and mobile number. Upon successful login, they enter their symptoms and select a hospital. Once a hospital receives this request and takes action (like administering vaccination), the patient has to approve it. Hospitals can then update medical records, which patients can later decrypt using their private keys

6. SECURITY

Security in the system is managed using blockchain. Every patient has a public-private key pair. Their private key is securely stored in a digital wallet like MetaMask. Whenever access is needed, the system uses these keys for authentication and authorization. The encryption ensures patient data is only accessed by trusted parties and remains secure even during sharing.

IV. IMPLEMENTATION

A. BLOCKCHAIN

Blockchain serves as the decentralized ledger that securely stores medical transactions and records. Each block in the chain contains encrypted data, timestamps, and links to previous blocks, ensuring data integrity and transparency. This technology ensures that no data can be modified without consensus across the network.

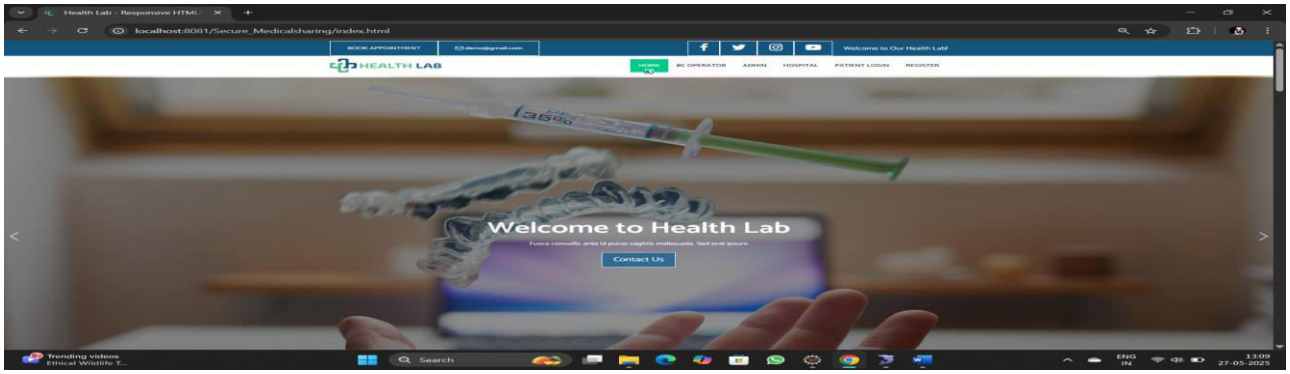
B. SMART CONTRACTS

Smart contracts are automated scripts stored on the blockchain. They self-execute when predefined conditions are met. Think of them like vending machines: you input the correct data, and the contract handles everything else no manual intervention needed. These contracts facilitate trust and eliminate the need for intermediaries.

C. ETHEREUM PLATFORM

Ethereum is the blockchain framework used in this project. It supports smart contract deployment and enables peer-to-peer transactions. Each transaction requires gas fees paid in Ether. Ethereum ensures that all actions, such as granting access to patient data, are transparent, secure, and immutable.

V. EXPERIMENTAL RESULTS



HOMEPAGE

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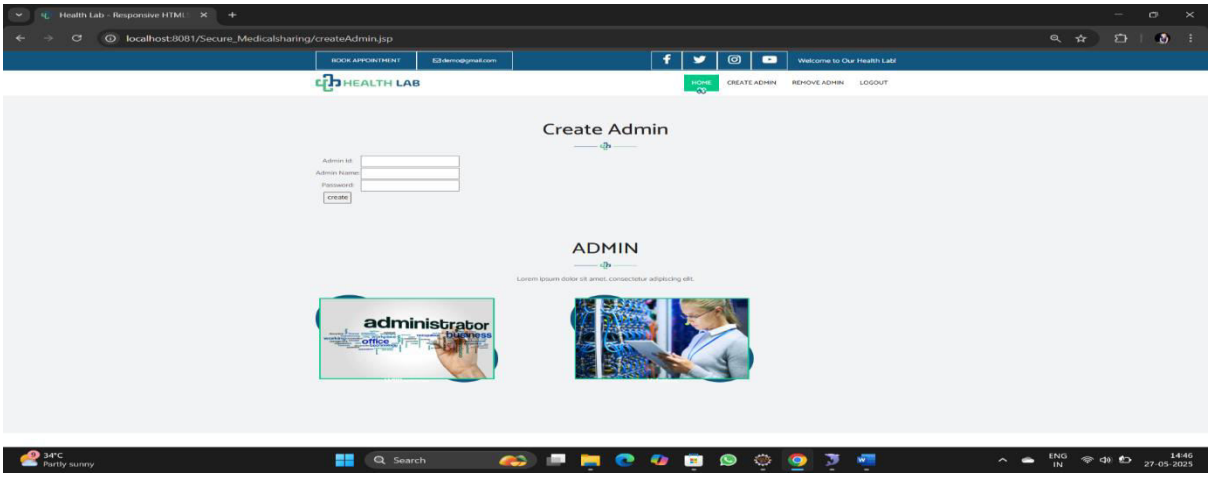
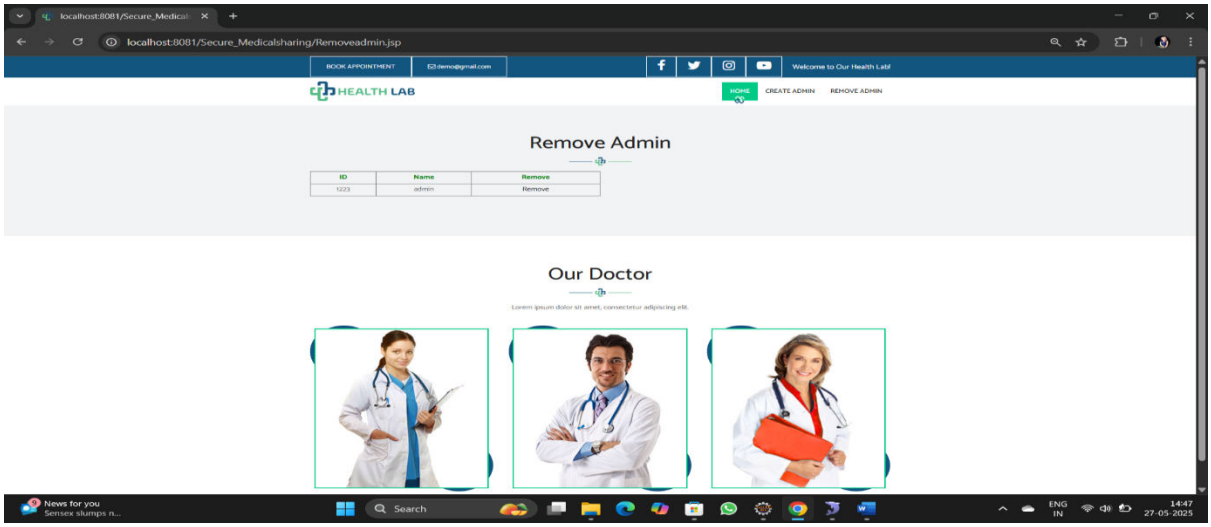
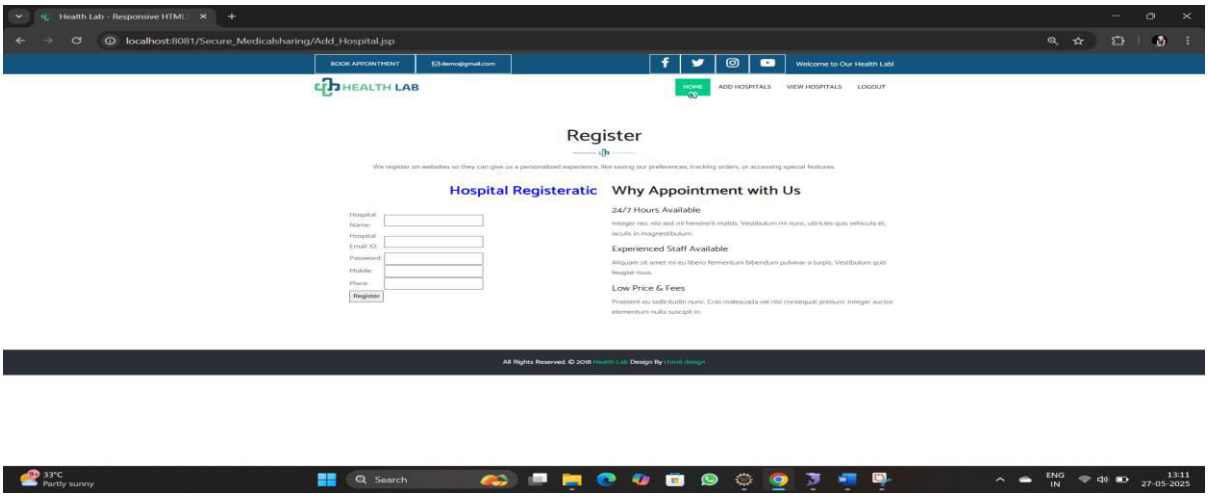


BC OPERATOR: CREATING /ADDING ADMINS



BC OPERATOR REMOVING ADMINS



HOSPITALS REGISTERATION AT ADMIN

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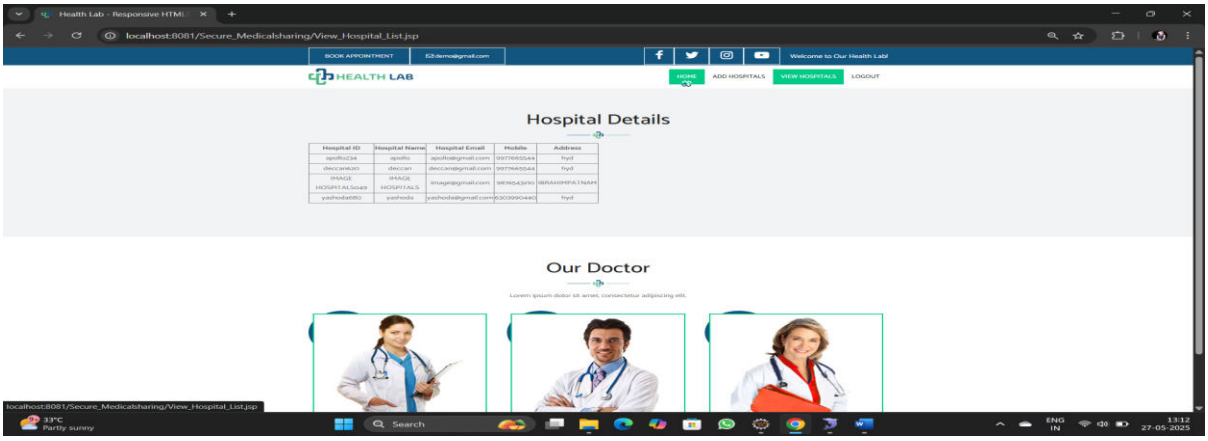
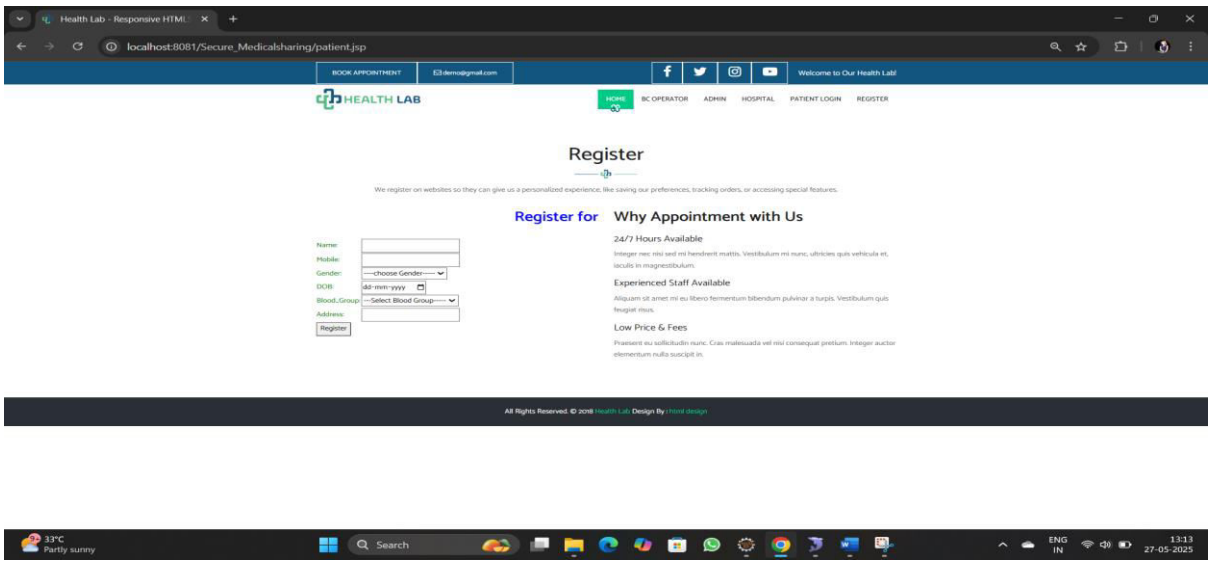
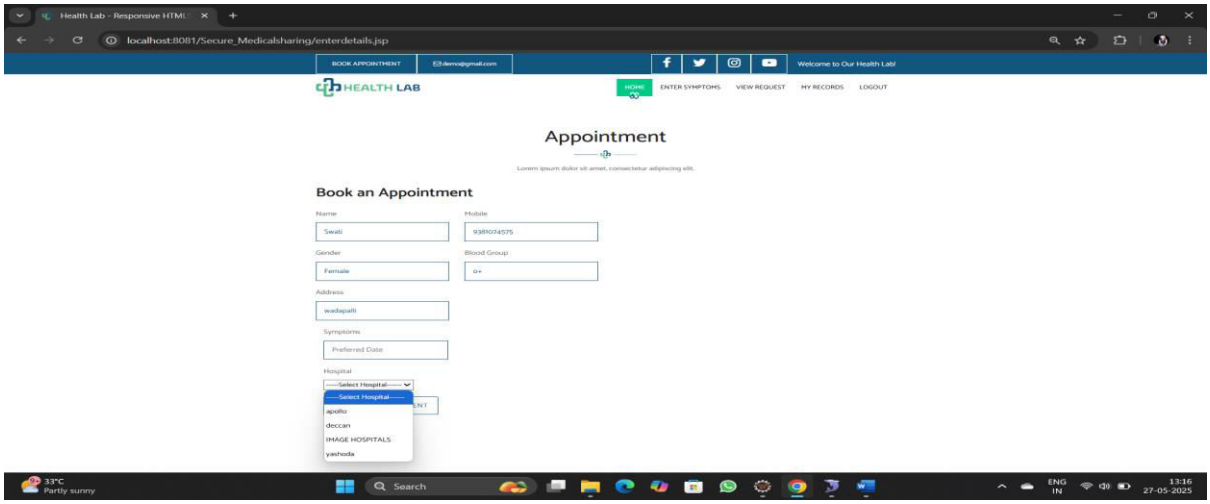


HOSPITALS DETAILS WITH THE ADMIN



PATIENT REGISTRATION PAGE



APPOINTMENT BOOKING PAGE OF THE PATIENT

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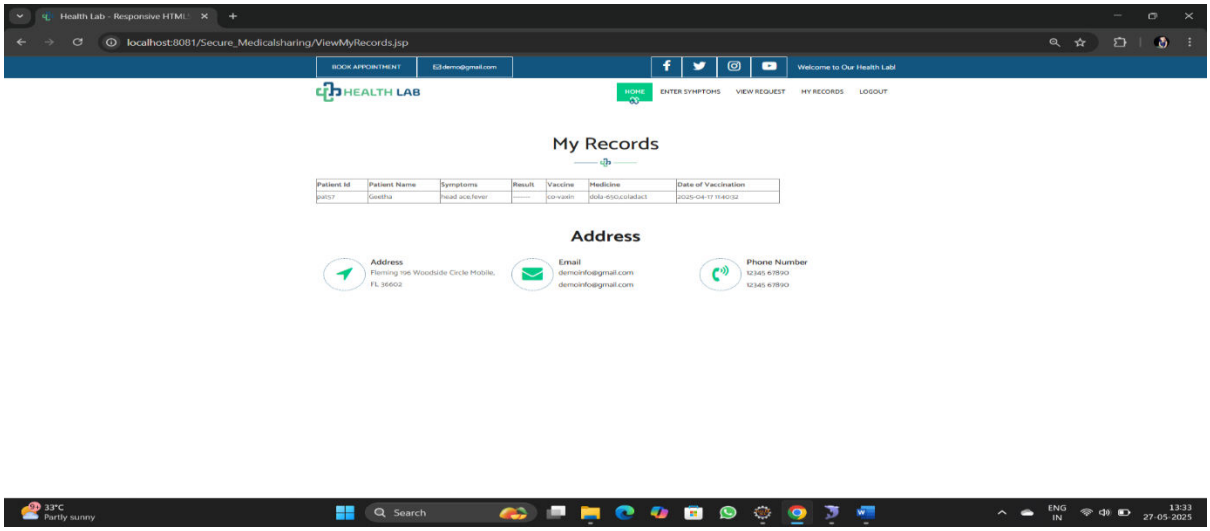
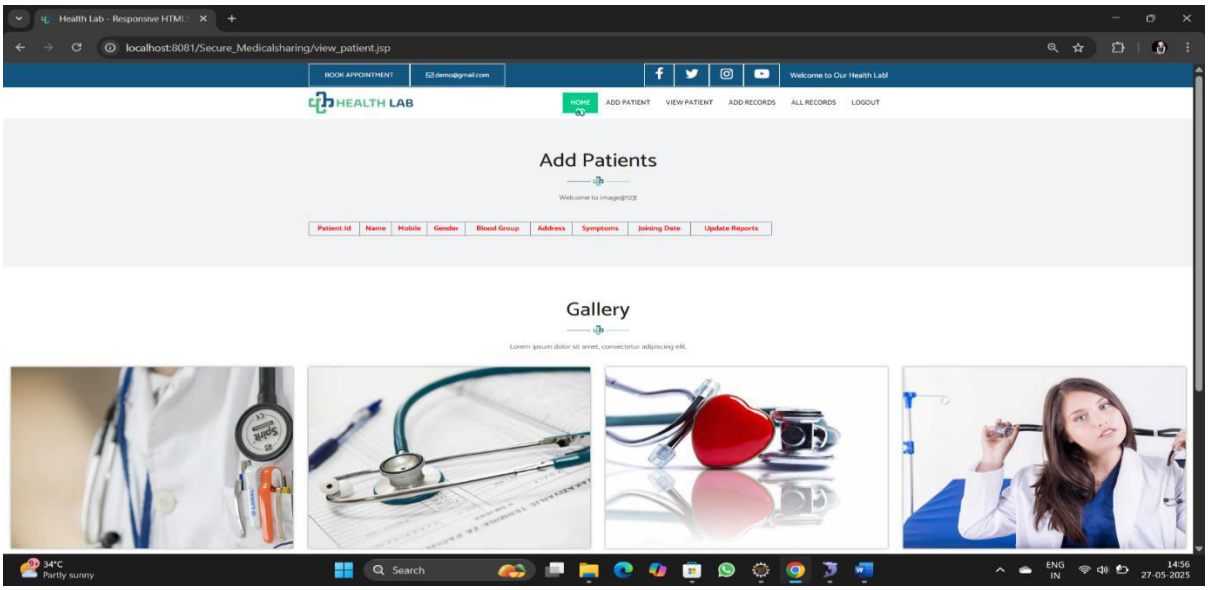


RECORDS OF THE PATIENT



HOSPITAL PAGE TO ADD VIEW PATIENTS AND THEIR RECORDS

V. CONCLUSION

The global battle against COVID-19 has shown how crucial it is to use advanced technologies to manage and control the spread of diseases. One major gap the pandemic revealed is the lack of smooth and secure data sharing in healthcare systems. Blockchain technology, known for its success in powering cryptocurrencies like Bitcoin and Ethereum, has great potential to address this issue. In this project, we introduced a novel framework for securely sharing medical data related to COVID-19. Unlike traditional systems that rely on centralized databases or private blockchains, we used a public Ethereum blockchain to run smart contracts and IPFS (InterPlanetary File System) to store medical records. This approach ensures greater transparency, higher security, and easier participation for users around the world. To enhance privacy, we applied a standard encryption method and proposed a custom decryption process. Moreover, we adopted the ChaCha20 encryption algorithm, which proved to be faster than the commonly used AES algorithm, thus improving performance. Overall, our work provides a practical, secure, and efficient solution for handling medical data in pandemic situations.

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VI. FUTURE ENHANCEMENT

Although our system performs well, it faces a few limitations. One major concern is scalability with Ethereum, which could be addressed in the future by shifting to other blockchain platforms designed for large-scale use, or by applying Ethereum scaling solutions like sharding. Another challenge is user accessibility. Non-technical users may struggle with digital wallets and interacting with decentralized web applications, which can hinder global adoption. Despite these hurdles, the framework we've built serves as a solid foundation. As blockchain technology continues to evolve, we expect more user-friendly tools and scalable solutions to emerge. In the long term, this approach can be refined and deployed during future health crises, ensuring that sensitive medical information remains in the control of patients—shared only with proper consent and protected with strong security measures. By doing so, blockchain has the potential to redefine how medical data is stored, accessed, and shared across healthcare systems worldwide.

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