MEDCARE: BLOCKCHAIN-BASED HEALTH RECORD EXCHANGE AND PATIENT ENGAGEMENT PLATFORM

Sharmila Rathod[1], Sahil Dighe[2], Shantanu Ekal[3], Pranav Gavli[4], Aditya Singh[5]

Department of Computer Engineering, MCT's Rajiv Gandhi Institute of Technology, Mumbai, India

*Emails: *1. sharmila.gaikwad@mctrgit.ac.in, 2. iroboton@gmail.com, 3. shantanuekal9@gmail.com, 4. gavlipranav2002@gmail.com, 5. adityashaileshsingh@gmail.com*

Abstract. MedCare is a cutting-edge medical app fostering seamless doctor-patient communication and secure data exchange. Using blockchain, it ensures immutable storage of health records, safeguarding against unauthorized access. Transparency is key, empowering patients with insight into their healthcare journey. The user-friendly interface facilitates real-time messaging and prescription management, streamlining healthcare interactions. Integrated payment processing ensures secure transactions. Built on Flutter, MedCare offers cross-platform compatibility for a cohesive user experience. Ultimately, MedCare revolutionizes healthcare by prioritizing data security, interoperability, and transparency, aiming to enhance overall healthcare quality and accessibility. MedCare's innovative approach addresses the pressing need for digital solutions in healthcare, offering a comprehensive suite of features tailored to modern demands. By prioritizing data security through blockchain technology and emphasizing transparent communication channels, it fosters trust and collaboration between patients and doctors. The platform's intuitive design ensures ease of use for both parties, facilitating efficient healthcare interactions. With its secure messaging system, prescription management, and seamless payment processing, MedCare streamlines the healthcare experience while improving patient outcomes. Overall, MedCare sets a new standard for healthcare technology, promising to revolutionize the delivery and accessibility of healthcare services for all.

Keywords: Medcare, Blockchain, Health Record Exchange, Patient Engagement Platform, Healthcare, Medical Records, Blockchain Technology, Decentralization, Data Privacy, Interoperability

1. INTRODUCTION

The rapid advancement of technology has brought about transformative changes in various sectors, and the healthcare industry is no exception. With the increasing digitization of medical records and the growing demand for patient-centered care, there is a pressing need for innovative solutions that ensure the secure exchange of health information while empowering patients to actively participate in their healthcare journey. In response to these challenges, we introduce Medcare, a pioneering blockchain-based health record exchange and patient engagement platform designed to bridge the gap between doctors and patients.

Medcare leverages the inherent features of blockchain technology to revolutionize the way medical records are managed, shared, and accessed. By utilizing a decentralized and immutable ledger, Medcare ensures the integrity and privacy of health data, thereby addressing concerns related to data breaches and unauthorized access. Moreover, the platform incorporates smart contracts to facilitate secure and transparent communication between healthcare providers and patients, enabling the seamless transmission of medical notes, reports, and prescriptions.

Central to MedCare's mission is its secure messaging system, which serves as the cornerstone of effective communication and collaboration in healthcare delivery. By leveraging advanced encryption algorithms and stringent authentication mechanisms, MedCare provides patients with a secure channel to engage directly with their healthcare providers, facilitating timely access to medical advice, discussing treatment plans, and addressing health concerns with confidence and confidentiality. Moreover, MedCare revolutionizes the traditional prescription management process by empowering doctors to seamlessly transmit prescriptions to patients through the app. With its user-friendly interface and intuitive design, MedCare enables healthcare professionals to generate accurate prescriptions and deliver them directly to patients, eliminating the need for cumbersome paper-based documentation and enhancing prescription accuracy, accessibility, and adherence. In addition to communication and prescription management, MedCare integrates seamless payment processing capabilities, enabling doctors to charge fees for services rendered through the app.

Leveraging cutting-edge tools such as MetaMask, Android Studio, Sepolia, and Flutter, MedCare ensures transparency and accountability in financial transactions, with fees deducted directly from the patient's MetaMask wallet. This innovative approach not only streamlines administrative processes but also fosters trust and confidence in the healthcare ecosystem. As a comprehensive medical app developed using a combination of industry-leading tools and technologies, MedCare represents a transformative force in healthcare delivery, offering a holistic solution that prioritizes patient-centric care, seamless communication, and enhanced accessibility. With its unparalleled commitment to data security, interoperability, and transparency, MedCare paves the way for a future where healthcare is not just efficient and effective but also empowering and inclusive. Through continuous innovation and dedication to excellence, MedCare sets the standard for the next generation of digital healthcare solutions, ensuring that patients receive the care they deserve in an increasingly connected world. MedCare stands as a testament to the relentless pursuit of excellence in healthcare innovation, offering a secure, intuitive, and transparent platform that bridges the gap between doctors and patients. At its core, MedCare embodies a steadfast commitment to data security, interoperability, and transparency, setting new benchmarks for the industry while ensuring the confidentiality, integrity, and accessibility of medical information.

2. REVIEW OF LITERATURE

Blockchain-Based Medical Records Secure Storage and Medical Service Framework

Yi Chen, Shuai Ding, Zheng Xu, Handong Zheng, Shanlin Yang

In the realm of patient care, accurate and comprehensive medical data represent a valuable asset. Safeguarding privacy and ensuring the secure storage of medical information are pivotal concerns within medical services. The imperative to securely store and effectively utilize personal medical records has consistently resonated with the broader populace. The advent of blockchain technology introduces a novel approach to address this challenge. By harnessing the attributes of decentralization, verifiability, and immutability, blockchain technology emerges as a promising solution for the secure storage of personal medical data. This paper outlines a meticulously crafted storage protocol that leverages both blockchain and cloud storage to effectively manage personal medical information. Additionally, the paper elucidates a service framework tailored for the purpose of sharing medical records.

Moreover, the unique characteristics of medical blockchain are meticulously presented and subjected to analysis through a comparative lens alongside traditional systems. Notably, the proposed storage and sharing paradigm operates independently of third-party intermediaries, thereby mitigating concentration of power and preserving equitable processing standards.

Service Framework Opportunities for Use of Blockchain Technology in Medicine

Igor Radanović, Robert Likić

Blockchain technology functions as a decentralized database that maintains a record of assets and transactions across a peer-to-peer network of computers. This network is fortified through cryptographic techniques, and as time progresses, the historical data becomes locked within interconnected and secure data blocks. This technology has notably found utility in realms such as cryptocurrencies, digital contracts, financial and public records, as well as property ownership. Its foreseeable applications are poised to extend into fields like medicine, science, education, intellectual property, and supply chain management.

In the realm of medicine, potential applications encompass diverse areas such as electronic health records, health insurance, biomedical research, drug procurement processes, and medical education. However, the adoption of blockchain technology presents certain challenges. Presently, the technology remains relatively nascent and lacks widespread public or expert understanding, which clouds the articulation of a definitive strategic vision for its complete potential. Critical issues include concerns regarding scalability, the security of smart contracts, and the rate of user adoption.Nonetheless, the future trajectory of blockchain technology is noteworthy, with projected capital investments of up to US$400 million in 2019. This underscores the significance that healthcare professionals and decision-makers should place on recognizing the transformative prospects that blockchain technology presents for healthcare organizations and medical practices.The intersection of block chain technology and healthcare has garnered significant attention in recent years due to its potential to address critical challenges in medical record management, data security, and patient engagement. This section provides an overview of key studies and developments in the field, highlighting the emergence of block chain-based solutions and their impact on the healthcare ecosystem.

Towards Using Blockchain Technology for eHealth Data Access Management

Nabil Rifi, Elie Rachkidi, Nazim Agoulmine, Nada Chendeb Taher

The significance of eHealth technology is steadily increasing, encompassing a spectrum ranging from remote access to Medical Records, including Electronic Health Records (EHR) and Electronic Medical Records (EMR), to real-time data exchange sourced from diverse on-body sensors across various patients. Amidst the extensive exchange of critical data, the landscape presents challenges and issues. Of paramount concern are matters of privacy and confidentiality, resonating deeply with both patients and authorized individuals engaged in data utilization. Concurrently, addressing scalability and interoperability stands as an equally pivotal aspect of the ultimate solution.

1) Blockchain Technology in Healthcare: Numerous studies have explored the applicability of blockchain technology in healthcare, emphasizing its decentralized nature, cryptographic security, and tamper-resistant properties (1). Blockchain offers a novel approach to secure data exchange, enabling transparent and immutable record-keeping while ensuring privacy and confidentiality (2).

2) Secure Medical Record Management: Traditional approaches to medical record management are plagued by inefficiencies, data silos, and security vulnerabilities. Blockchain-based solutions have emerged as promising alternatives, enabling secure and interoperable health data exchange among disparate systems (3). By decentralizing data storage and implementing cryptographic techniques, blockchain mitigates the risk of data breaches and unauthorized access (4).

3) Patient-Centric Care and Empowerment: The shift towards patient-centric care has fueled the development of platforms that empower individuals to take control of their health data and participate actively in their care journey. Blockchain technology facilitates patient engagement by providing secure access to medical records, enabling patients to share data with healthcare providers, researchers, and other stakeholders (5). Empowering patients with greater visibility and ownership of their health information fosters trust, transparency, and collaboration in the healthcare ecosystem (6).

4) Challenges and Considerations: Despite the potential benefits, the adoption of blockchain technology in healthcare presents various challenges and considerations. Scalability, interoperability, regulatory compliance, and data privacy are among the key factors that influence the implementation and deployment of blockchain-based solutions (7). Addressing these challenges requires a multidisciplinary approach involving collaboration between technologists, healthcare professionals, policymakers, and regulatory bodies (8).

5) Case Studies and Pilot Projects: Several pilot projects and initiatives have demonstrated the feasibility and efficacy of block chain-based solutions in healthcare. Projects such as Medrek, Health Link, and Medical Chain have explored various use cases, including secure medical record management, prescription tracking, and clinical trials management (9). These case studies provide valuable insights into the real-world applications of block chain technology and highlight its potential to transform the healthcare industry.

2.1 LITERATURE TABLE

#	Author Name	Scope	Research Gap	Summary
1	Yi Chen, Shuai Ding, Zheng Xu, Handong Zheng, Shanlin Yang	Secure storage and sharing of medical records using blockchain and cloud storage.	Lack of widespread adoption and understanding of blockchain-based medical record systems.	Presents a storage protocol using blockchain and cloud storage for managing personal medical information.
2	Igor Radanović, Robert Likić	Overview of blockchain technology's potential applications in medicine.	Nascent technology with scalability and security concerns.	Discusses the potential of blockchain in various medical applications amid challenges.
3	Nabil Rifi, Elie Rachkidi, Nazim Agoulmine, Nada Chendeb Taher	Blockchain for secure and scalable eHealth data exchange.	Need for secure, scalable solutions for medical data exchange.	Emphasizes blockchain's role in secure and scalable medical data exchange.
4	Yongle Chen, Hui Li, Kejiao Li, Jiyang Zhang	Improved P2P file system scheme combining IPFS and blockchain.	High-throughput and storage problems in existing P2P file systems.	Proposes an improved P2P file system with blockchain for data reliability and availability.
5	Peng Zhang, Douglas C. Schmidt, Jules White, Gunther Lenz	Blockchain use cases in healthcare, focusing on data sharing and interoperability.	Challenges in data sharing and interoperability in healthcare.	Identifies use cases and design considerations for blockchain in healthcare.
6	Henrique Rocha, Stéphane Ducasse	Modeling Blockchain Oriented Software (BOS).	Lack of standard modeling notations for BOS.	Discusses the need for specialized modeling notations for BOS.
7	Min Xu, Xingtong Chen, Gang Kou	Systematic review of blockchain research in business and economics.	Early stage of blockchain research development in business and economics.	Performs a systematic review of blockchain research, identifying key themes.
8	H. Sami Ullah, S. Aslam, N. Arjomand	Applications and developments of blockchain in healthcare.	Exploring beyond EHR for blockchain applications in healthcare.	Explores diverse blockchain applications in healthcare beyond EHR storage.
9	Matthias Mettler	Potential applications of blockchain in healthcare.	Increasing application in healthcare beyond financial services.	Examines blockchain's potential in improving patient care and operational efficiency in healthcare.
10	Nishara Nizamuddin, Haya R. Hasan, Khaled Salah (Authenticity)	Ensuring the authenticity of online publications using IPFS and blockchain.	Authenticity of digital content in online publications.	Proposes a solution for ensuring the originality and authenticity of digital content.

3. BACKGROUND

A) Evolution of Healthcare Management Records

1) Paper-Based Records: Historically, healthcare records were maintained on paper. These records included handwritten notes, charts, and documents detailing patient information, medical history, treatments, and diagnoses. While paper-based records served their purpose, they were inherently limited in terms of accessibility, portability, and scalability. Retrieving and sharing patient information was often time-consuming and prone to errors, especially as healthcare facilities grew in size and patient volumes increased.

2) Electronic Medical Records (EMRs): The advent of computers and digital technology led to the development of electronic medical records (EMRs). EMRs digitize patient health information, making it easier to record, store, and retrieve damagers typically focus on the clinical aspects of patient care, including medical history, diagnoses, medications, and laboratory results. They improve efficiency by enabling healthcare providers to access patient information quickly and securely within their own healthcare organization.

3) Electronic Health Records (EHRs): Electronic health records (EHRs) represent a more comprehensive and interoperable approach to healthcare record management. Unlike EMRs, which are confined to individual healthcare facilities, EHRs aim to create a longitudinal record of a patient's health information that can be shared across different healthcare organizations and settings. EHRs integrate data from multiple sources, including hospitals, clinics, pharmacies, laboratories, and imaging centers. This interoperability enhances care coordination, continuity, and patient safety.

4) Interoperability Challenges: Despite the benefits of EHRs, interoperability remains a significant challenge in healthcare record management. Different healthcare systems often use proprietary formats and standards for data storage and exchange, making it difficult to share information seamlessly between systems. Interoperability barriers hinder care coordination, increase administrative burdens, and limit patients' ability to access and control their health information.

5)Emerging Technologies and Future Directions: Recent advancements in technologies such as blockchain, artificial intelligence (AI), and cloud computing offer new opportunities to address interoperability challenges and improve healthcare record management. Blockchain technology, in particular, holds promise for secure and decentralized health record exchange, enabling patients to have greater control over their data and ensuring data integrity and privacy.

B) Challenges in Traditional Health Record Methods

Health data is often fragmented across various systems, including electronic medical records (EMRs), electronic health records (EHRs), specialized clinical systems, and paper-based records. This fragmentation makes it challenging to aggregate and access a comprehensive view of a patient's health information.

Interoperability refers to the ability of different healthcare information systems to exchange and use data seamlessly. In many cases, healthcare systems use proprietary formats and standards, leading to interoperability issues. Lack of interoperability inhibits the sharing of patient data between different healthcare organizations, providers, and systems, resulting in fragmented care and duplication of efforts. Even within healthcare organizations, data may be siloed in different departments or specialty areas. For example, radiology departments may use separate systems for imaging data, while laboratory data is stored in a different system. Data silos hinder care coordination and prevent healthcare providers from accessing a comprehensive view of a patient's health history and treatment.

Traditional health record exchange methods raise concerns about data security and privacy. Patient health information is sensitive and must be protected from unauthorized access, breaches, and cyberattacks. Centralized systems that store large volumes of patient data present attractive targets for hackers and cybercriminals, posing risks to patient confidentiality and trust.

Current methods of health record exchange, such as faxing, mailing, or manual data entry, are often slow, cumbersome, and error-prone. Healthcare providers may spend significant time and resources managing paperwork and administrative tasks. Inefficiencies in data sharing can lead to delays in patient care, redundant tests and procedures, and increased healthcare costs.

Traditional health record exchange methods may not adequately engage patients in managing their own health information. Patients often have limited access to their medical records and may face barriers in requesting or sharing their data with other providers. Empowering patients to access, control, and contribute to their health records is essential for promoting patient-centered care and improving health outcomes.

4. MEDCARE AND ITS SIGNIFICANCE

Medcare is a blockchain-based health record exchange and patient engagement platform designed to revolutionize the way healthcare records are managed, shared, and accessed. Built on blockchain technology, Medcare offers a decentralized and secure infrastructure for storing, exchanging, and managing health data.

Significance in Healthcare:

1) Improved Data Security and Privacy: One of the primary advantages of Medcare is its ability to enhance data security and privacy. By leveraging blockchain technology, Medcare ensures that patient health information is encrypted, immutable, and tamper-proof. This reduces the risk of data breaches and unauthorized access, thereby enhancing patient confidentiality and trust.

2) Enhanced Interoperability: Medcare addresses the interoperability challenges faced by traditional health record exchange methods. By providing a standardized and decentralized platform for data exchange, Medcare enables seamless interoperability between different healthcare systems, organizations, and providers. This improves care coordination, reduces duplication of efforts, and facilitates better clinical decision-making.

3) Empowering Patients: Medcare places a strong emphasis on patient engagement and empowerment. Through user-friendly interfaces and self-management tools, patients can access, control, and contribute to their health records securely. This empowers patients to take an active role in managing their health information, making informed decisions, and collaborating with healthcare providers to optimize their care.

4) Streamlined Workflow and Efficiency: By automating and streamlining health record management processes, Medcare enhances workflow efficiency for healthcare providers. Tasks such as data entry, retrieval, and sharing are simplified, reducing administrative burdens and freeing up valuable time for patient care. This results in improved productivity, reduced costs, and better patient outcomes.

5) Innovation and Future Growth: Medcare represents a catalyst for innovation and future growth in healthcare. As a cutting-edge blockchain solution, Medcare paves the way for new applications and services that leverage decentralized technologies to address emerging challenges in healthcare delivery. By fostering collaboration and innovation, Medcare contributes to the continuous improvement of healthcare systems worldwide.

5. IMPLEMENTATION DETAILS

A) Blockchain Components Used

1) Infura: Infura is a popular infrastructure provider for Ethereum-based applications. It offers developer's easy access to Ethereum and IPFS (InterPlanetary File System) networks without the need to run their own Ethereum or IPFS nodes. This allows developers to focus on building their applications without worrying about the complexities of maintaining and scaling the underlying infrastructure. Infura provides APIs that allow developers to interact with the Ethereum blockchain and IPFS network through simple HTTP requests. This includes methods for querying blockchain data, sending transactions, and more. Many decentralized applications (DApps), wallets, and other Ethereum-based projects rely on Infura's infrastructure to connect to the Ethereum network reliably and securely. By using Infura, developers can offload the heavy lifting of running Ethereum and IPFS nodes to a trusted provider, which helps reduce costs and complexity while improving reliability and scalability for their applications.

2) Sepolia: Sepolia is a robust Ethereum testnet that seamlessly transitioned from Proof of Work to Proof of Stake, mirroring the Ethereum mainnet. It offers developers a reliable platform to deploy and experiment with Solidity smart contracts. To facilitate the development process, Sepolia provides a convenient faucet service. This ensures that developers exclusively utilize Sepolia ETH for gas when staging their decentralized applications on the testnet.

3) MetaMask: MetaMask is a popular cryptocurrency wallet and decentralized application (DApp) browser extension that allows users to interact with the Ethereum blockchain directly from their web browsers. Developed by ConsenSys, MetaMask enables users to securely store, send, and receive Ethereum and other ERC-20 tokens, as well as access decentralized applications such as decentralized exchanges, games, and financial services. One of MetaMask's key features is its seamless integration with web browsers like Chrome, Firefox, and Brave, making it easily accessible to a wide range of users. With its intuitive user interface and robust security features, including encryption and password protection, MetaMask has become a trusted tool for millions of individuals and businesses worldwide to engage with the decentralized web. Additionally, MetaMask supports Ethereum's network of smart contracts, allowing users to interact with decentralized applications and participate in token sales and crowdfunding campaigns directly from their wallets. As blockchain technology continues to evolve and gain mainstream adoption, MetaMask remains at the forefront, empowering users to explore and engage with the decentralized ecosystem securely and conveniently.

B) IDE and UI Framework

1) Android Studio: Android Studio is the cornerstone of modern Android app development, offering a comprehensive suite of tools and features tailored to streamline the entire development lifecycle. As the official integrated development environment (IDE) backed by Google, Android Studio provides developers with a user-friendly interface designer, a powerful code editor with intelligent code completion and refactoring capabilities, and a built-in emulator for testing applications across various device configurations. With support for both Java and Kotlin programming languages, developers can leverage their preferred language to craft innovative and responsive mobile experiences. Android Studio's seamless integration with version control systems like Git, along with its robust debugging and performance profiling tools, empowers developers to build, test, and optimize their applications with confidence. Regular updates from Google ensure that Android Studio remains at the forefront of Android app development, continually evolving to meet the needs of developers worldwide.

2) Flutter: Flutter is a revolutionary framework for building cross-platform applications, developed by Google. It empowers developers to create stunning, natively compiled applications for mobile, web, and desktop from a single codebase. With its reactive programming model and expressive UI components, Flutter enables developers to craft beautiful and highly performant user interfaces that adapt seamlessly to

various screen sizes and device platforms. One of Flutter's standout features is its hot reload capability, allowing developers to instantly see the effects of their code changes without losing the app's state, thus facilitating rapid iteration and experimentation during the development process. Flutter's rich set of pre-designed widgets, along with its extensive support for customizations and animations, empowers developers to bring their creative visions to life with ease. Furthermore, Flutter's strong community support, comprehensive documentation, and growing ecosystem of packages and plugins contribute to its rapid adoption and popularity among developers worldwide. Overall, Flutter represents a game-changing solution for building modern, engaging, and versatile applications across different platforms.

6. RESULTS AND DISCUSSION

The MedCare Mobile Application revolutionizes healthcare accessibility, offering users seamless access to appointments, text chat consultations, and prescription management from their smartphones. With features like health record access, it empowers users to take charge of their health conveniently. Through secure messaging and emergency assistance features, it ensures effective communication and support during critical moments, enhancing overall healthcare experiences.

A) Login Screen

The following image shows the login screen for the application Medcare. Which accepts address and private key of the user to authenticate, after which role selection is done.

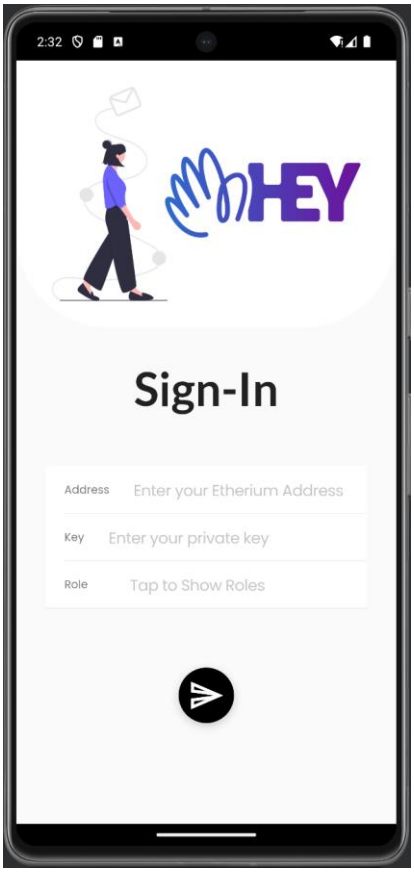

Fig.6.1

B) Patient Dashboard

The following image show the Patient dashboard which has his own wallet address at the top and a list of medical records. It also includes an option to authorize doctor from which the patient wants consultation

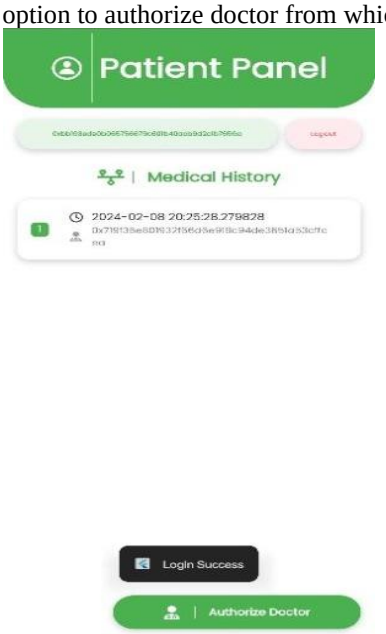

Fig.6.2

C) Doctor Dashboard

The following image show the Doctor dashboard which has his own wallet address. There is a feature to adjust the fee the doctor would receive for his/her consultation. After which he/she can give prescription to the patient which has authorized him/her.

Fig.6.3

7. CONCLUSION

In conclusion, the "MedCare" harnesses the robust capabilities of blockchain technology to reimagine healthcare delivery. Through the use of the Sepolia test network with Infura's reliable endpoints, combined with the versatility of Android Studio and Flutter for mobile development, MedCare provides a fortified platform for patient-doctor interactions. It empowers patients with a dedicated panel to authorize physicians, ensuring an additional layer of security and autonomy over their medical data. For healthcare providers, the doctor panel streamlines the process of prescribing medication and facilitates the efficient handling of consultation fees. This project stands as a testament to the innovative application of blockchain within the medical field, offering a scalable, secure, and user-centric mobile application that caters to the critical needs of both patients and healthcare professionals. MedCare is poised to set a new standard in healthcare management, providing peace of mind through enhanced security, improved trust, and a seamless user experience.

REFERENCES

[1] M. Young, The Techincal Writers Handbook. Mill Valley, CA: University Science, 1989.

[2] Yi Chen, Shuai Ding, Zheng Xu, “Blockchain-Based Medical Records Secure Storage and Medical”, Nov 2019.

[3] Igor Radanović, Robert Lekic, “Service Framework Opportunities for Use of Blockchain Technology in Medicine”, July 2018.

[4] Min Xu, Gang Kou, “A systematic review of blockchain”, May 2019.

[5] Rud Ramani Gyawali Singha, Manan Lad, Gaurav Mukesh Shipbroker, Anish Rehear, Chandar Chauhan, Nilesh Rathod, “Dynamic Pose Diagnosis with Blaze Pose and LSTM for Spinal Dysfunction Risk Estimation”, Feb 2022.

[6] Sandeep Pandey, Gajendra K, “Applications of Blockchain towards Healthcare”, Dec 2018.

[7] Nilesh Rathod, Sunil Wankhade, “Optimizing neural network based on cuckoo search and invasive weed optimization using extreme learning machine approach”, April 2022.

[8] Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System.

[9] Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System.

[10] Kuo, T., Kim, H. E., & Ohno-Machado, L. (2017). Blockchain distributed ledger technologies for biomedical and health care applications. Journal of the American Medical Informatics Association, 24(6), 1211-1220.

[11] Ekblad, A., Azaria, A., Halima, J. D., & Lippman, A. (2016). A case study for blockchain in healthcare: “Medrek” prototype for electronic health records and medical research data.

[12] Zhang, P., & Schmidt, D. C. (2018). White paper: Blockchain technology in healthcare: A systematic review. IEEE Open Journal of Engineering in Medicine and Biology, 1, 131-144.

[13] Swan, M. (2015). Blockchain: Blueprint for a new economy. O'Reilly Media, Inc.

[14] Gordon, W. J., Catalini, C., & Teitelbaum, A. (2018). Blockchain technology for healthcare: Facilitating the transition to patient-driven interoperability. Computational and Structural Biotechnology Journal, 16, 224-230.

[15] Agbo, C. C., Mahmoud, Q. H., & Eklund, J. M. (2019). Blockchain technology in healthcare: A systematic review. Healthcare, 7(2), 56.

[16] Mettler, M. (2016). Blockchain technology in healthcare: The revolution starts here. In eHealth 360° (pp. 457-462). Springer, Cham.

[17] Yüksel, M., & Tekin, N. (2020). Blockchain in healthcare: A systematic literature review, applications, challenges, and future research directions. Journal of Medical Systems, 44(9), 1-17.