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Electronic Health Record Management System using RFID: Improving Efficiency and Accuracy in Healthcare

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Abstract

This research presents the development and implementation of an Electronic Health Record Management System (EHRMS) using Radio Frequency Identification (RFID) technology. The study discusses the limitations of traditional paper-based health record systems and highlights the benefits of integrating RFID technology in healthcare settings. The EHRMS streamlines patient identification and data capture processes, enhances data accuracy, and improves overall healthcare delivery. Real-time synchronization ensures up-to-date and easily accessible patient records, empowering healthcare providers to make informed decisions and provide timely interventions. The paper concludes with the potential impact of the RFID-based EHRMS in transforming healthcare record management and improving patient outcomes.

Keywords: Electronic Health Record Management System, RFID, Radio Frequency Identification, Data Accuracy, Realtime Synchronization, and Healthcare Delivery

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1. Introduction

A. Background

In the healthcare industry, effective management of electronic health records (EHRs) is crucial for delivering high-quality and efficient patient care. However, traditional paper-based methods for storing and accessing health records have become outdated and inefficient, leading to errors and limited accessibility [7-10]. To address these challenges, the integration of Radio Frequency Identification (RFID) technology has emerged as a promising solution. RFID utilizes radio waves to identify and track objects or individuals equipped with RFID tags automatically. This technology offers a more streamlined approach to healthcare record management. The implementation of an Electronic Health Record Management System (EHRMS) using RFID technology has the potential to revolutionize healthcare record management. By combining RFID tags with patient identification, the EHRMS streamlines record management, enhances data accuracy, and improves patient care. RFID technology automates patient identification, eliminating manual entry errors, and ensuring up-to-date as well as easily accessible EHRs[11-15]. Real-time synchronization with the EHRMS empowers healthcare providers to make a well-informed decision, leading to better diagnosis and treatment outcomes. In summary, RFID-based EHRMS holds the promise of streamlining workflows, enhancing data accuracy, and ultimately transforming the delivery of healthcare services [16-18].

B. Problem Statement

The existing paper-based management of electronic health records (EHRs) in healthcare systems is associated with inefficiencies, limited accessibility, errors in data entry, and lack of real-time synchronization, hindering the delivery of timely and accurate healthcare services. This fragmented approach to note down and manage the healthcare records poses challenges in terms of data accuracy, collaboration among healthcare professionals, and the efficient utilization of resources [19-21]. There is a critical need for an Electronic Health Record Management System (EHRMS) that integrates Radio Frequency Identification (RFID) technology to automate patient identification, enable real-time data capture, and establish seamless synchronization across healthcare facilities. The systematic problem is to develop an EHRMS using RFID technology that overcomes the limitations of paper-based systems,

improves data accuracy, enhances collaboration, and optimizes resource utilization for efficient and effective healthcare delivery.

C. Motivation

The motivation behind developing an EHRMS using RFID technology is driven by the limitations of traditional paper-based health record systems. The need for a more efficient, accurate, and accessible approach to healthcare record management is evident. RFID technology offers the opportunity to automate patient identification and data capture processes, reducing the administrative burdens, and improving workflow efficiency. By eliminating errors associated with manual entry and enabling real-time synchronization, RFID-based EHRMS enhances data accuracy , empowers healthcare providers to make informed decisions, as well as improves patient care and satisfaction. The transformative potential of RFID technology in healthcare record management, further drive the motivation for developing an RFID-based EHRMS.

D. Objectives

The objectives of the EHRMS research are to develop an Electronic Health Record Management System using RFID technology and achieve real-time synchronization with the electronic health record database. By implementing RFID-based patient identification and data capture, the research aims to improve efficiency, data accuracy, and patient care within healthcare facilities.

2. Literature Review

The adoption of Radio Frequency Identification (RFID) technology in Health care settings have garnered significant attention due to its potential to revolutionize various aspects of patient care and healthcare management. This literature review examines several research studies that highlight the benefits and applications of RFID in electronic health records (EHR), patient identification, data capture, and overall healthcare practices.

[1] Yao, Chu, and Li (2012) conducted a comprehensive literature review on RFID adoption in healthcare and hospitals, using a formal innovation decision framework to analyze its current state. The study revealed RFID's promising applications, including asset tracking,

patient identification, and real-time data access. While RFID demonstrated functional value in these areas, several barriers to adoption, such as technological limitations, cost, privacy concerns, and lack of global standards was identified.

[2] Ngai, Poon, Suk, et al. (2009) contributed to the advancement of RFID technology by designing an RFID-based Healthcare Management System. This study showcased RFID''s potential to transform healthcare practices and optimize resource allocation. The integration of RFID technology with other emerging technologies, such as the Internet of Things (IoT), enabled continuous patient monitoring and personalized medicine, offering new dimensions of patient care.

[3] Rahman (2018) conducted research on RFID technology for managing patient medical files in government hospitals in Saudi Arabia. The study highlighted RFID's popularity and effectiveness in identifying objects and items from a close distance, making it a promising tool for healthcare applications. The ability to quickly and easily track and identify patient medical records show- cased RFID's potential in enhancing data management and improving patient outcomes.

[4] Sankaranarayanan and Udayasuriyan (2020) explored biometric secured Electronic Health Records (EHR) and developed a frame-based biometric authentication system to improve EHR security. By reducing the False Rejection Ratio (FRR) and False Acceptance Ratio (FAR), the system ensured a balance between security and user convenience, providing a robust solution for protecting patient data and privacy.

[5] The research by Rodrigues et al. (2012) investigated RFID technology in E-Health, emphasizing its role in patient and staff identification, tracking, and monitoring. By enabling better resource allocation, reducing medical errors, and increasing patient independence, RFID demonstrated its potential to enhance patient care and healthcare efficiency.

[6] Liu and Wang (2013) introduced an RFID-based Electronic Medical Record (EMR) system in the Neonatal Intensive Care Unit (NICU), showcasing rapid information sharing, error reduction, and enhanced NICU management. RFID's versatility in seamlessly integrating into patient wristbands or ID cards, improving patient tracking efficiency, and advancing neonatal healthcare.

In conclusion, the integration of RFID technology into healthcare holds immense promise for transforming patient care and healthcare management. From streamlining electronic health records and patient identification to enhancing security and privacy, RFID's potential impact is evident across various healthcare applications. As advancements in RFID technology continue to unfold, its role in revolutionizing healthcare practices is set to play a vital role in shaping the future of the healthcare industry.

3. Methodology

The research was conducted in the following ways:

A. Requirement Analysis

A comprehensive analysis of the requirements for the RFID-based Electronic Health Record Management System (EHRMS) was conducted, taking into account the needs of healthcare providers, patients, and administrators. Key functionalities and features of the system were defined.

B. System Design

Based on the identified requirements, a detailed system design for the EHRMS was created. The web application was developed using HTML, CSS, React, and Django. Hardware integration involved NodeMCU, RFID Scanner RC522, and RFID cards. Django Rest Framework (DRF) was used to manage API and data on the server side, facilitating seamless communication between client-side applications and server-side components.

Figure.1 illustrates the system architecture and integration of the Electronic Health Records Management System (EHRMS). The web application serves as the primary user interface, developed using HTML, CSS, React, and Django. This front end allows healthcare professionals and administrators to access and interact with the EHRMS.

The server-side components are managed using the Django Rest Framework (DRF), which provides an API layer for handling data and communication with the client-side applications. DRF ensures seamless integration between the web application and the server, enabling real-time data exchange and updates.

To enhance the security and accessibility of the EHRMS, hardware integration is implemented. The hardware components include NodeMCU, RFID Scanner RC522, and RFID cards. The NodeMCU acts as the bridge between the web application and the hardware devices, facilitating communication and data transfer between the two.

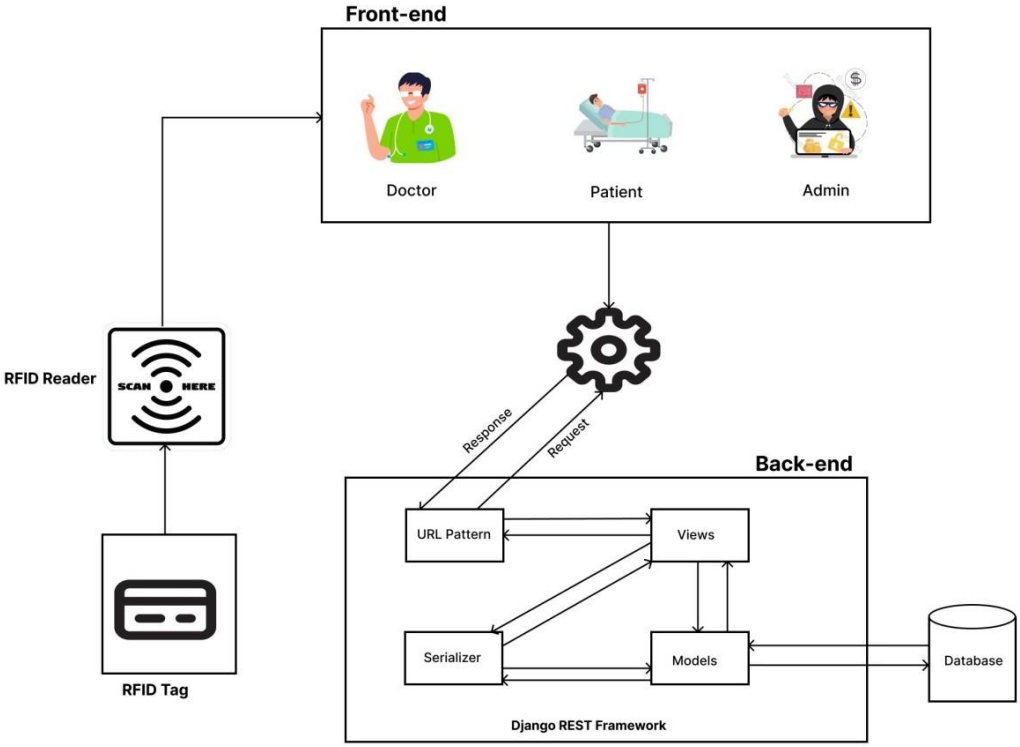

Figure 1. EHRMS System Architecture and Integration

The RFID Scanner RC522 is responsible for scanning the RFID cards, which contain patient identification information. When a healthcare professional or staff member uses their RFID card, the scanner reads the data and communicates it securely to the web application through NodeMCU. This allows authorized personnel to access patient records and perform various actions based on their privileges within the EHRMS.

Overall, Figure 1 showcases a comprehensive view of the EHRMS system, highlighting the seam- less integration of web technologies, server-side components, and hardware devices to create an efficient and secure electronic health records management system.

C. Web Development

The web application was developed using HTML, CSS, React, and Django, with modules for patient registration, data capture, real-time synchronization, and access control. The use case diagram depicted various use cases and interactions with actors in a clear and concise manner.

The use case diagram illustrates the functionalities and interactions of the Electronic Health Records Management System (EHRMS) with three primary actors: Admin, Doctor, and Patients.

1. Actors

a. Admin: Represents the system administrator who manages user accounts, system configurations, and overall EHRMS administration.

b. Doctor: Represents healthcare professionals who use the EHRMS to access and update patient records, view medical history, and manage treatments.

c. Patients: Represents individuals who are the subjects of the health records and can access their own medical information through the patient portal.

2. Use Cases

a. Login: All actors can log in to the EHRMS using their respective credentials.

b. Manage User Accounts: Admin can manage user accounts, including creating new accounts, granting permissions, and resetting passwords.

c. View Patient Records: Doctors can view patient medical records, including medical history, test results, and treatment plans.

d. Update Medical Information: Doctors can update and add new medical information to a patient's record.

e. Access Patient Portal: Patients can access their own medical records through a secure patient portal.

f. Generate Reports: Doctors and Admin can generate reports based on patient data for analysis and decision-making.

3. Interactions

- All actors interact with the EHRMS through the web application's user interface developed using HTML, CSS, React, and Django.

- The Django Rest Framework (DRF) manages API and data on the server-side, facilitating seamless communication between the client-side applications and server-side components.

The use case diagram in Figure. 2 provides a visual representation of the primary actors (Admin, Doctor, and Patients) and the specific functionalities they can perform within the EHRMS. It showcases the interactions between the actors and the system, allowing a clear understanding of the user roles and their capabilities in managing electronic health records.

Figure 2. EHRMS Use Case Diagram

D. Hardware Integration

In parallel with web development, hardware components including RFID Scanner RC522, RFID cards, NodeMCU, breadboard, and jumper wires were integrated. The

NodeMCU was programmed to communicate with the RFID scanner and capture data from RFID cards, which was then sent to the web application for processing.

The RFID-based EHRMS research successfully implemented Python, Django, React, JavaScript, HTML, and CSS, along with hardware components, to create a functional and reliable system.

4. Results and Analysis

The implementation of the RFID-based EHRMS has yielded positive results. It has streamlined workflows, reduced administrative burdens, and improved data accuracy in patient identification and data capture. Real-time synchronization ensures healthcare providers have access to up-to-date patient information, enhancing decision-making and patient care. The successful implementation of the EHRMS showcases the potential of RFID technology in revolutionizing healthcare record management.

As shown in Figure.3, the designed web page for the Electronic Health Records Management System (EHRMS) has the following layout and features:

Header Section

- **Logo:** A logo is placed in the top left corner, representing the EHRMS brand or organization.
- **Navbar:** In the top right corner, there is a navigation bar with three options: Home, About, and Contact Us. Clicking on these options will direct users to the respective sections of the website.

Main Content Section

- **Login Sections:** The main content area of the page contains three distinct login sections for each actor in the EHRMS: Admin, Doctor, and Patients. Each login section includes input fields for username and password, and a “Login” button to authenticate the user.

Footer Section

- **Copyright Information:** At the bottom of the page, there is a copyright section displaying the relevant copyright details, indicating ownership of the website's content.

- **Social Media Links:** On the side of the copyright information, there are icons representing various social media platforms. These icons serve as clickable links that allow users to connect with the EHRMS organization through their respective social media channels, including Facebook, Twitter, Instagram, YouTube, and GitHub.

The images presented in Figure.4 through Figure.7 offer valuable insights into the EHRMS web application's user interface. These visuals effectively demonstrate the application's functionalities and user experience.

Figure.4 introduces the specialized "Doctor Panel," is designed to meet the specific needs of medical professionals. This interface allows doctors to efficiently manage patient information and medical records.

Figures.5 and Figure.6 highlights the distinct "Patient Panel" and "Admin Panel," catering to the unique requirements of patients and administrators. These screenshots emphasize user-centered design and ease of interaction within these panels.

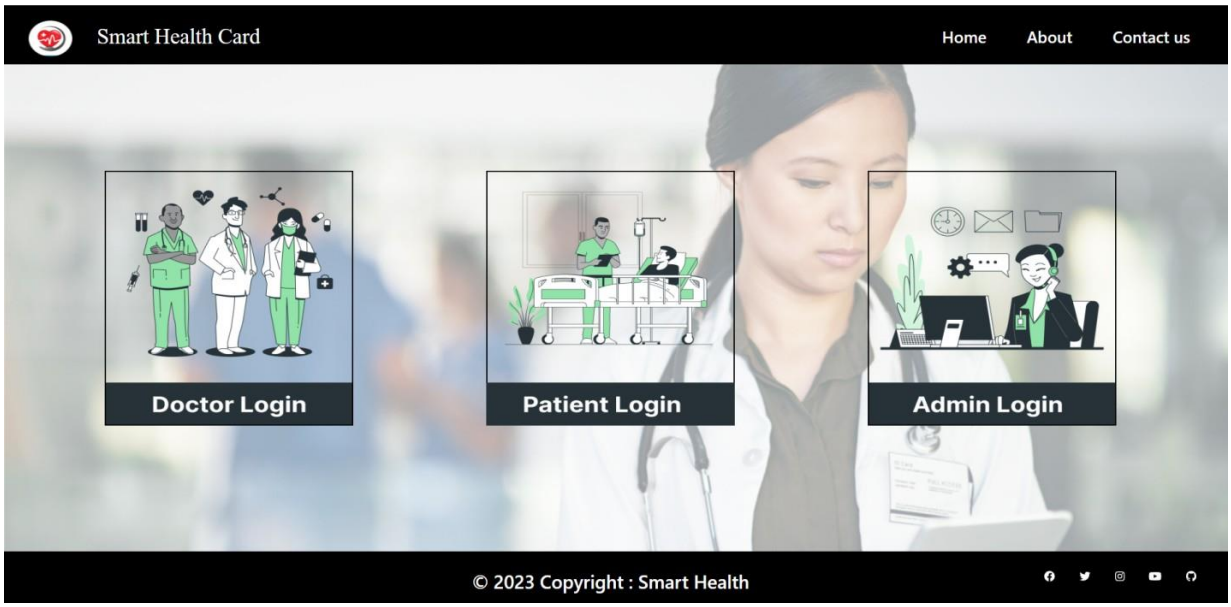

Figure 3. Snapshot of Designed Web Page

Figure 4. Doctor Panel

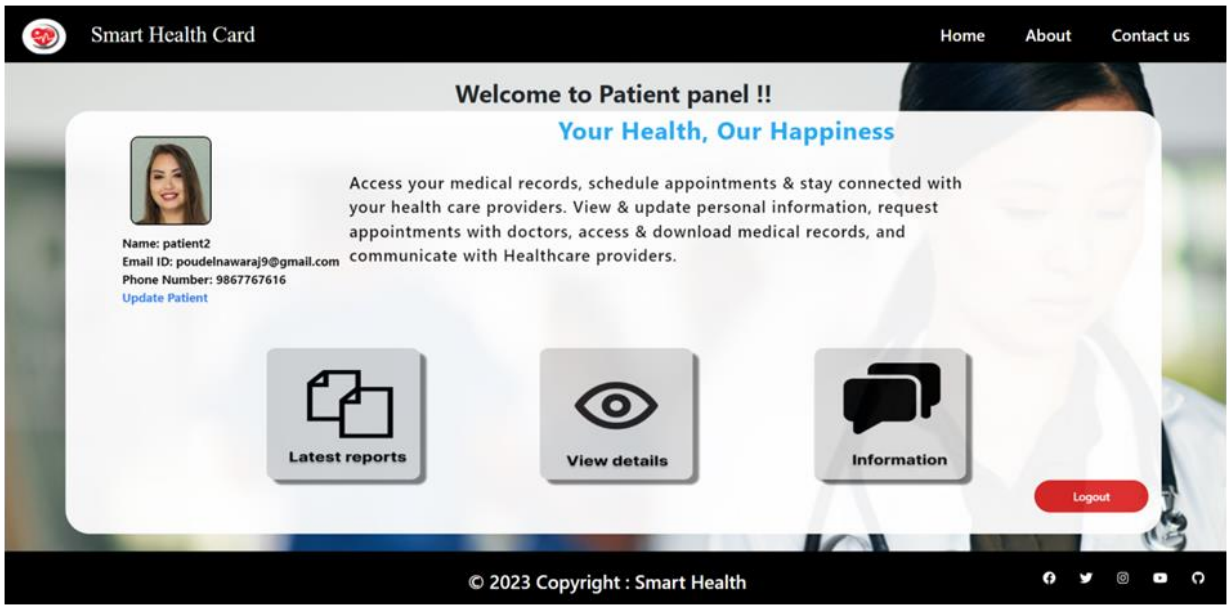

Figure 5. Patient Panel

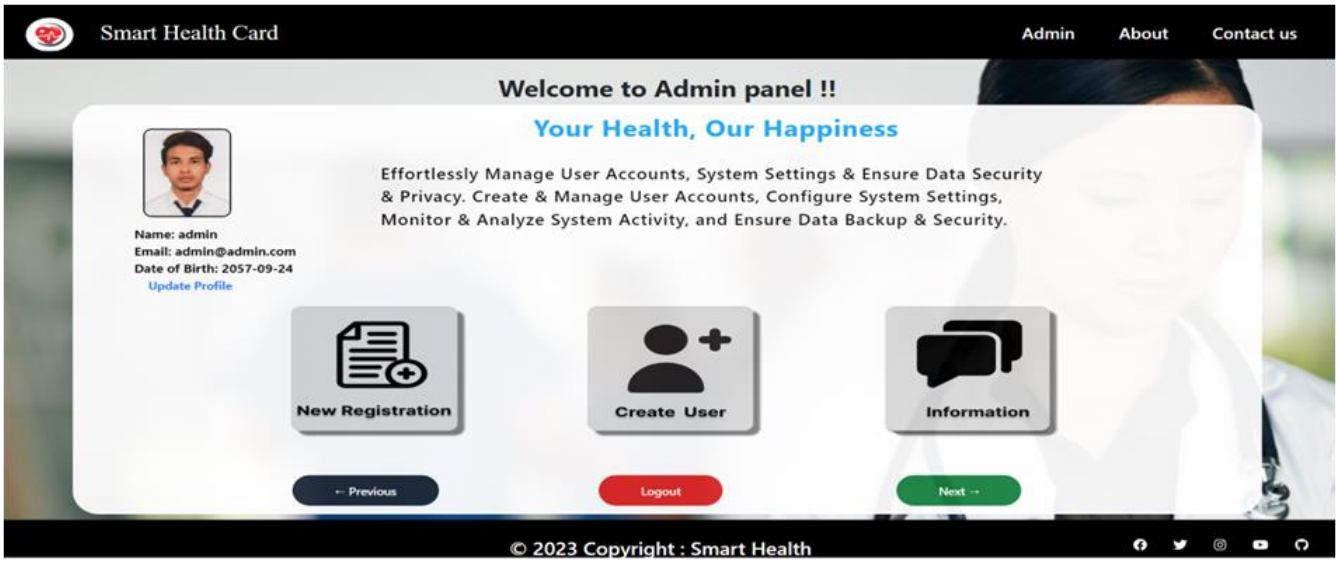

Figure 6. Admin Panel

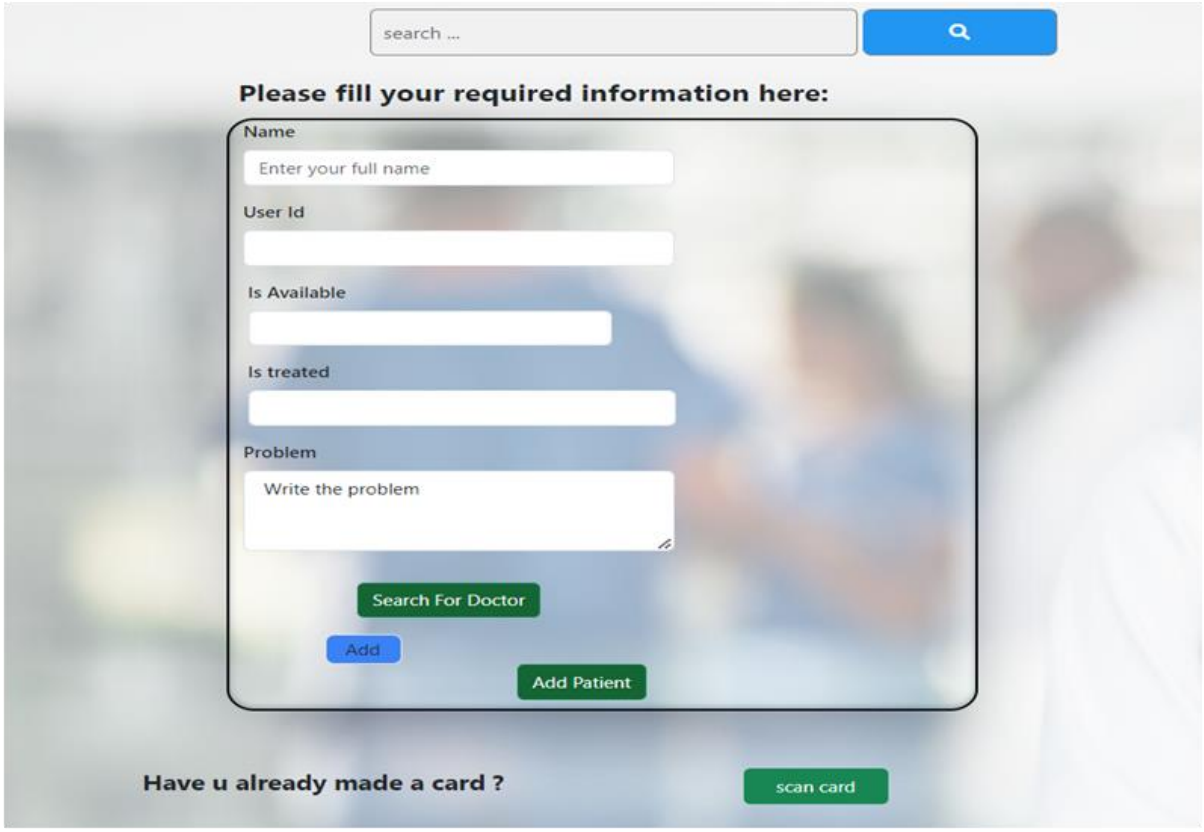

Figure 7. Search Doctor & Add Patients Page

Notably, Figure.7 displays the “Search Doctor & Add Patients” page, streamlining the process of locating healthcare providers and incorporating new users. This feature enhances

user accessibility and supports the application's user base growth. The website is in development phase and will be deployed in near future.

Overall, the showcased screenshots provide an overview of the EHRMS application's features, emphasizing intuitive design, functionality, and the ability to serve various user roles.

5. Limitations and Future Enhancements

Limitations of the RFID-based EHRMS include the range limitations of RFID technology, potential tag interference, cost considerations, privacy and security concerns, and integration complexities. Future enhancements could focus on improving RFID range and accuracy, developing miniaturized and versatile tags, enhancing security measures, improving interoperability, incorporating advanced analytics, integrating with IoT devices, and developing mobile applications.

6. Conclusion

In conclusion, the RFID-based EHRMS addresses the limitations of traditional paper-based health record systems. It offers advantages such as automated patient identification, improved data accuracy, streamlined workflows, and enhanced patient care. The motivation behind developing the RFID-based EHRMS lies in the desire to improve efficiency, data accuracy, and patient care. The research objectives include developing an RFID-enabled EHRMS and achieving real-time synchronization. The methodology involves requirement analysis, system design, web development, and hardware integration. The results and analysis showcase the positive impact of the RFID-based EHRMS. Limitations and future enhancements highlight areas for improvement. Overall, the RFID-based EHRMS has the potential to transform healthcare record management and contribute to improved patient outcomes.

Declarations

Ethical Approval

The research paper titled "Electronic Health Record Management System using RFID: Improving Efficiency and Accuracy in Healthcare" is approved for review and access.

Competing Interests

The authors wish to declare that there are no competing interests as defined by Springer, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

Author's Contributions

A.S., G.P., J.Y., N.P., and K.R.K. made substantial contributions to the conception and design of the research. A.S. and G.P. collected and analyzed the data. J.Y. and N.P. developed the RFID-based Electronic Health Record (EHR) Management System and conducted the system's validation. K.R.K. supervised the entire research process.

All authors contributed to the interpretation of the results and were actively involved in drafting and critically revising the manuscript. A.S. and G.P. primarily wrote the main manuscript text, while J.Y. and N.P. prepared figures and illustrations. K.R.K. provided critical feedback and performed a thorough review of the manuscript.

The final version of the manuscript was read, revised, and approved by all authors, ensuring its accuracy and integrity.

Each author has participated sufficiently in the work to take public responsibility for appropriate portions of the content. All authors agree to be accountable for the accuracy and integrity of the research presented in this manuscript.

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Availability of Data and Materials

The authors declare that the data and materials supporting the findings of this study are available upon request. Additionally, the preprint version of the article is available as a preprint in Research Square at the following link: https://doi.org/10.21203/rs.3.rs-3200967/v1.

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