Design and Implementation of a Web-Based Patient Management System for Hospital Operations

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ABSTRACT

A Patient Management System (PMS) is a software solution designed and implemented to automate and streamline tasks in healthcare organizations. This project focuses on the design and implementation of a web-based PMS aimed at addressing the problems presented by conventional methods of patient's management, such as manual, time-consuming record-keeping, inaccuracy of data, and inefficiency and ineffectiveness in patient care. The PMS leverages modern web technologies such as Next.js, Tailwind Cascading Style Sheet (CSS), TypeScript, Hypertext Preprocessor (PHP) and MySQL. It offers a single platform for maintaining patient information, appointment scheduling, patient bills and Electronic Medical Records (EMRs) on a centralized platform. The PMS can therefore guarantee quick access to all essential patient information due to the conversion of traditional paper-based processes to a paperless, streamlined, and automated process. Various components of the system include; a doctor and other healthcare professionals, administration staff, and friendly user interface design for ease of navigation and communication. It also involves security features such as access control and secure communication protocols that will keep sensitive information safe and maintain all compliances regarding healthcare. This project follows the incremental development methodology and assures responsiveness and flexibility based on the feedback provided by the users during system development. The system addresses privacy and security through encryption, role-based access control, and user authentication. Scalability is ensured via a modular and cloud-compatible architecture. Initial evaluations were conducted in a simulated clinic environment, with future plans for real-world deployment. With an improved level of patient engagement and operational efficiency, this web-based PMS is poised to meaningfully contribute toward the digital transformation of healthcare services to provide better outcomes and satisfaction in improving patient engagement and operational efficiency.

Keywords: Patient Management System (PMS), Electronic Medical Records (EMR), Appointment Scheduling, Web-Based System, Healthcare

INTRODUCTION

A key element of societal well-being is the delivery of healthcare, and hospitals are essential to the supply of medical services. Effective and efficient healthcare delivery is, however, severely hampered by the continued use of antiquated, paper-based systems in many healthcare facilities. Delays, inaccuracies, inadequate data accessibility, and disjointed communication across hospital departments are frequently linked to manual patient data handling. These inefficiencies lower overall patient satisfaction, raise administrative burdens, and have a detrimental effect on the quality of service. A Patient Management System (PMS), according to Smartsheet (2019), is a software program created to overcome these constraints by automating and simplifying crucial hospital procedures.

This research aims to create and deploy a web-based PMS that offers a centralized platform for scheduling appointments, managing medical records, and processing billing all while guaranteeing quick and safe access to patient data. This technology improve collaboration among healthcare practitioners, increase efficiency, and

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decrease human error by substituting automated digital workflows for existing manual techniques. The study's goals are to research the literature on existing patient management techniques, create a secure and user-friendly PMS, and assess its efficacy using feedback mechanisms and system testing.

This project employs a modular development methodology, putting in place a system architecture that meets hospital administrative and clinical requirements. In particular, the system facilitates features like scheduling appointments, managing invoicing, tracking medical records, and patient registration. Physicians, nurses, pharmacists, hospital administrators, and patients are the system's main users. It is anticipated that the PMS will close communication gaps and encourage improved clinical decision-making by guaranteeing data security, interoperability, and accessibility. Notably, this survey does not currently cover services like telemedicine, AI-based analytics, or remote monitoring.

By cutting down on paperwork, easing administrative burdens, and facilitating prompt medical action, this study has the potential to revolutionize healthcare delivery. According to Patel et al. (2020), web-based systems improve resource management and data accessibility, which greatly increases hospital efficiency. Additionally, the system promotes greater patient autonomy and involvement by allowing individuals to manage appointments and access their medical records online. This is in line with contemporary healthcare trends, which emphasize patient-centered care and digital transformation more and more.

According to Huda et al (2013), the PMS also guarantees adherence to strict data protection laws as the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA). The system protects private medical data from unwanted access by implementing role-based access control, secure authentication, and encrypted data storage. This initiative is a relevant and significant addition to hospital management practices in both local and global contexts, given the increasing demand for strong digital infrastructures in the healthcare industry.

Problem Statement

Digital technology has advanced, but many hospitals still manage patient data using paper-based methods, which leads to inefficiencies, human error, and data loss. Patient treatment is jeopardized, communication between healthcare providers is impeded, and access to vital medical information is delayed. Moreover, the lack of a centralized, secure system raises questions over adherence to laws like GDPR and HIPAA, which require stringent protections for patient privacy. Hospitals struggle to fulfill today's requirements for patient happiness and operational efficiency without a strong digital infrastructure. This emphasizes how clinical and administrative tasks must be integrated into a safe and user-friendly platform using a complete, web-based PMS.

LITERATURE REVIEW

Web-Based Clinical Decision Support System

Rudin et al (2025) created a web-based clinical decision support system designed to help medical professionals make diagnoses and treat lower back pain. The usability of the system was evaluated by physicians and patients using an iterative, user-centered design methodology. Clinical decision automation dramatically decreased diagnostic uncertainty and increased treatment efficiency, according to the study. Appointment scheduling, billing integration, and centralized medical record handling are only a few of the essential features that a comprehensive PMS should have. Nevertheless, this tool simplified decision-making for a particular medical condition.

Web-Based Intervention for Middle Managers in Healthcare

Gil-Hernández et al. (2025) created and executed a web-based intervention platform aimed at middle managers in the healthcare industry in a different study. Through the use of agile development methodologies and usability evaluations, the platform sought to improve communication, leadership, and resilience in medical settings. Although the intervention was successful in improving managerial decision-making and administrative workflow, it did not expand its capability to include patient care elements that are necessary for an end-to-end

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PMS, such as health records, appointments, or invoicing. This restriction draws attention to the current systems' limited emphasis on organizational management as opposed to comprehensive patient care.

ConciliaMed: A Web-Based Tool for Chronic Medication Reconciliation.

ConciliaMed, a web-based tool for chronic medication reconciliation, was presented by Ciudad-Gutiérrez et al. (2025). The platform used cloud computing and data integration techniques to improve medication adherence and decrease prescription errors. The system effectively closed gaps between patients and providers by encouraging collaborative decision-making in the management of chronic diseases; however, its functionality was limited to pharmacological aspects and lacked core hospital operations like appointment tracking, EMR storage, or billing, making it ineffective as a comprehensive PMS solution.

Web-Based Medication Reconciliation Tool

Last but not least, Basri (2025) created a web-based queue information system to reduce patient wait times and expedite clinic outpatient services. This system's real-time organization and display of queue data substantially increased patient flow and operational efficiency. Although the technology greatly improved clinic operations, it ignored more general patient management issues including documentation upkeep, diagnosis monitoring, and safe money transactions. The system's influence was therefore limited to front desk operations and did not support the wider range of hospital management requirements that a comprehensive PMS ought to cover.

METHODOLOGY

Design Model

This project used the Incremental Software Development Life Cycle (SDLC) approach, which enables modular integration, iterative development, and ongoing end-user input. This approach worked especially well for creating a web-based PMS, which needed complicated functions like bill management, appointment scheduling, and medical records to be integrated in modules. Because the paradigm encourages continuous improvement, it is simpler to handle problems as they emerge and take stakeholder input into account for later stages of development. The implementation of each main module billing, EMR, registration, and authentication was done in phases, beginning with the most basic features and working up to more complex ones. User Acceptance Testing was carried out to assess usability, security, and performance following the completion of each module. Ultimately, the model contributed significantly to the overall stability, maintainability, and user satisfaction of the final system.

Development Tools

A modern full-stack web development toolkit was used in the creation of the PMS. Because of its effectiveness and database integration features, PHP was utilized as the backend scripting language. Next.js, which is based on React.js, and Tailwind CSS were utilized to create a dynamic and responsive frontend experience. The web pages' structural structure was supplied by HTML. The system used MySQL, a powerful relational database renowned for its speed, reliability and ease of use for data management. Visual Studio Code was used for development, and Postman was utilized for Application Programming interface validation and Cross Platform Apache MYSQL PHP Perl (XAMPP) for local server testing. Git and GitHub were used to manage version control and teamwork. Finally, Selenium for user interface and cross-browser functionality testing and Jest for unit testing provided automated testing capability.

Functional Modules

i. The Patient Management System is made up of seven main modules that were created to provide safe patient data management and effective hospital workflow:

ii. Authentication and Access Control: Role-based login is used to guarantee safe and limited access according to user roles (e.g., admin, patient, doctor).

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iii. Patient Dashboard and Registration: Provides a single location for patients to access appointments, records, and billing, as well as to create and manage profiles.

iv. Appointment Scheduling: Allows patients to make or change appointments and get email confirmations.

v. Electronic Medical Records: Authorized personnel can more easily store and retrieve diagnoses, prescriptions, and treatment histories digitally.

vi. Bill Management: Payment history can easily be tracked; invoices and receipt can also be easily generated.

vii. Privacy and Security: SSL/TLS encryption for data transmission, and secure authentication through session management and password hashing to guarantee security and privacy. To maintain legal compliance, it also complies with relevant data protection laws.

System Architectural design

The system architecture of the Web-Based PMS is made to guarantee data confidentiality, scalability, and effective workflow automation across hospital departments. The Presentation Layer, Application Layer, and Database Layer make up its three-tier architecture, each of which is in charge of different but connected tasks.

The presentation layer (user interface): This layer offers a web-based interface that is responsive and easy to use. It was created with Next.js with Tailwind CSS. Patients, physicians, pharmacists, administrative staff, billing officers, and receptionists all use it as their primary point of contact. Both desktop and mobile access are supported by the interface's cross-device interoperability and ease of use.

Application Layer (Business Logic & Application programming Interface (API)): This intermediary layer manages the communication between the database and the user interface via the business logic and API. It was created in PHP and handles user requests, enforces access control policies, and makes sure that tasks like creating bills, booking appointments, and updating medical records are carried out in accordance with role-based permissions and system rules.

Database Layer (Data Storage): This layer, which is driven by MySQL, is in charge of safely keeping and administering all hospital data, such as patient records, appointment schedules, invoices, and login passwords. To preserve data integrity and maximize efficiency, the database structure is normalized. User credentials are hashed to prevent unwanted access, and sensitive data is safeguarded by secured storage methods.

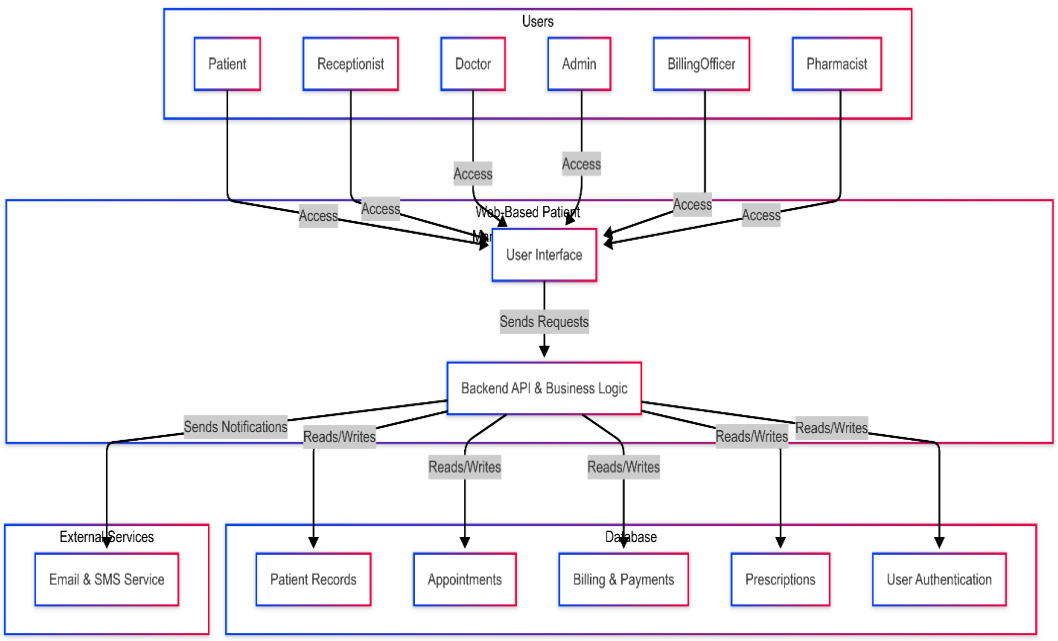

Figure 1: System Architecture Diagram of the web-based PMS

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Unified Modelling Language Diagrams

Unified Modeling Language (UML) diagrams are crucial for illustrating the organization and communication of the web-based PMS. These diagrams aid in comprehending the architecture, processes, and connections between various parts of the system. The UML diagrams shown below are pertinent to this project:

Use Case Diagram

The relationship between users (actors) and the features of the system is depicted in the use case diagram. It demonstrates how various user roles engage with the web-based patient management system, including patients, physicians, billing officers, receptionists, pharmacists, and administrators.

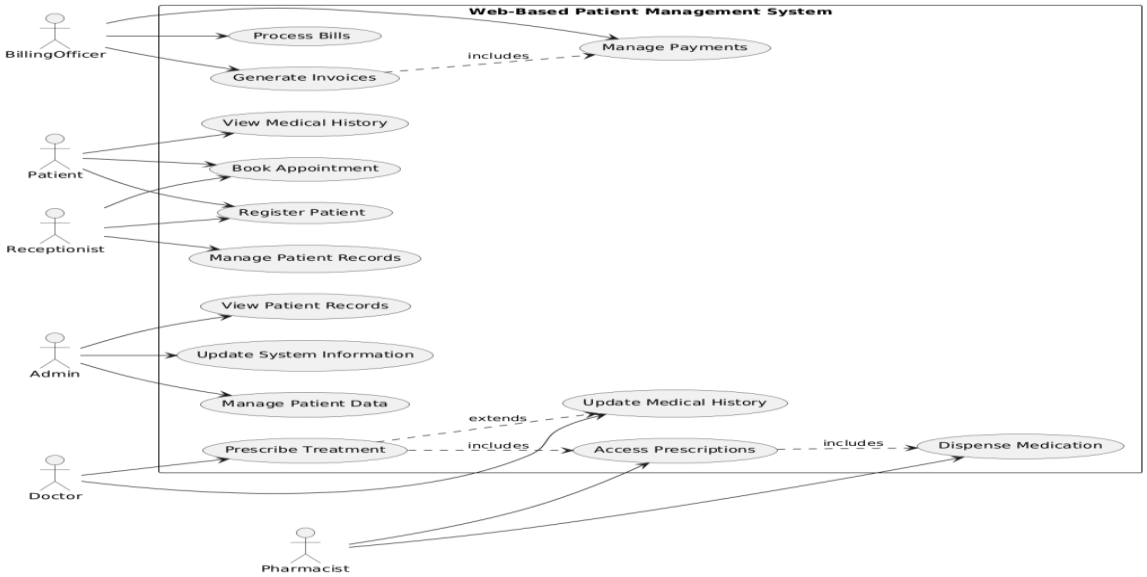

Figure 2: Patient Management System Use Case diagram

Sequence Diagram

The sequence diagram simulates how messages move over time between various system components such as the patient, web-based system, backend and doctors. It facilitates comprehension of how requests are handled and answers are produced.

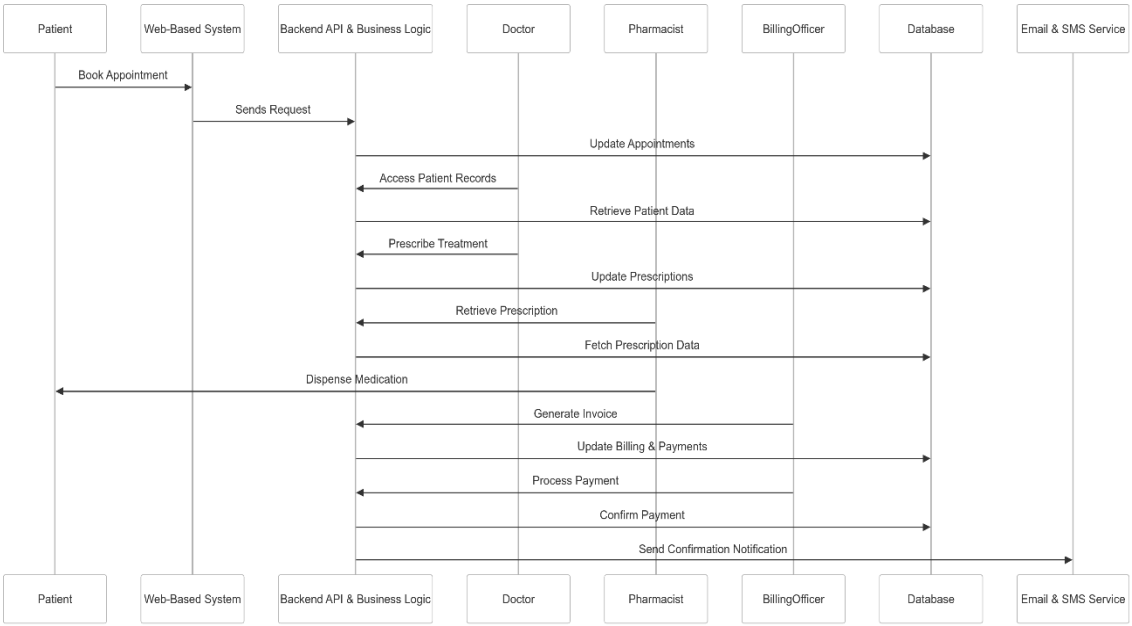

Figure 3: Patient Management System Sequence Diagram

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RESULT

The PMS was tested in a controlled environment using dummy data sets that represented real-world hospital operations. It did well in terms of responsiveness and data handling. Security tests ensured that unauthorized access was effectively blocked, and encrypted data transmission was verified. While the system is currently suited for small to mid-sized clinics, the underlying architecture allows for expansion. Future deployment in a live setting will provide further insights into system robustness.

Patient Registration page

The patient registration page allows patient create accounts so that they can access the patient management system. On registration a automatically generated hospital number is sent to their email which they can use to login.

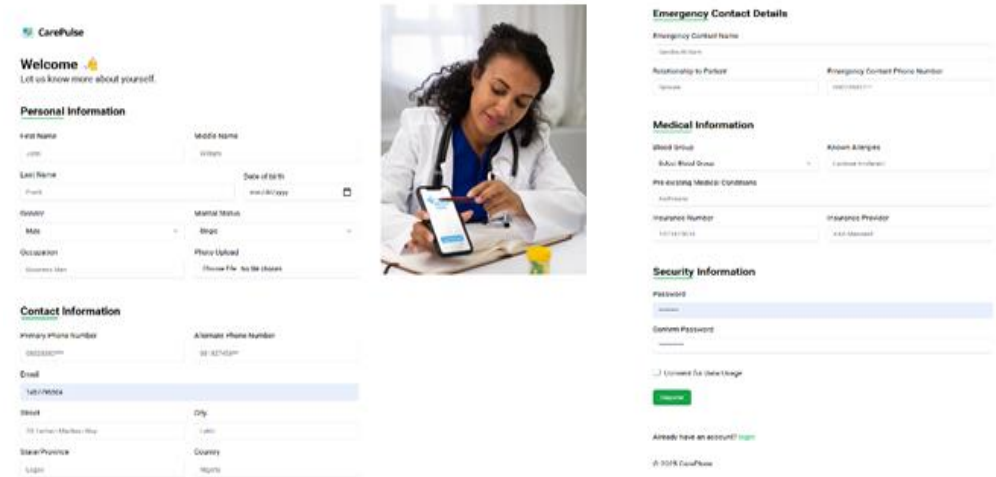

Figure 4: Patient Registration Page

Login Pages

The patient login page allows registered patients to securely access the system using their hospital number which is sent to the users email after a successful registration and password which is hashed in the database. The admin login page allows registered staff members to access the system using their email and password which is also hashed.

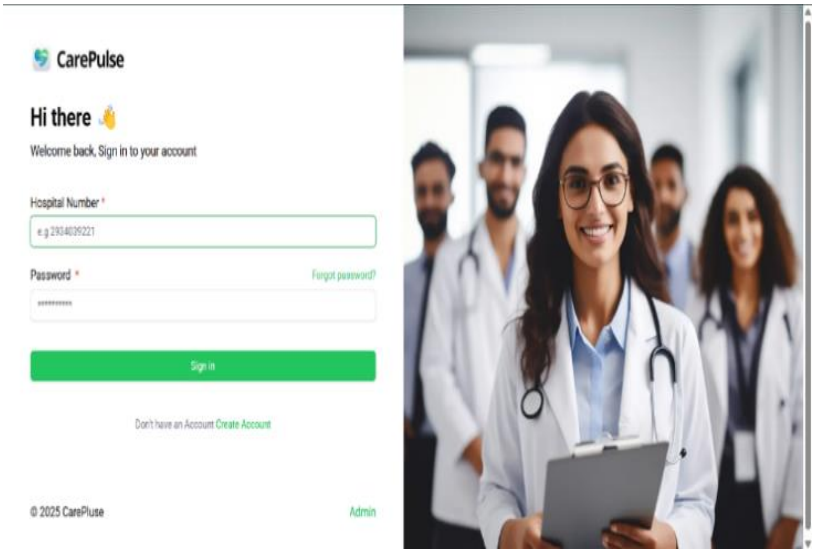

Figure 5: Patient Login Page

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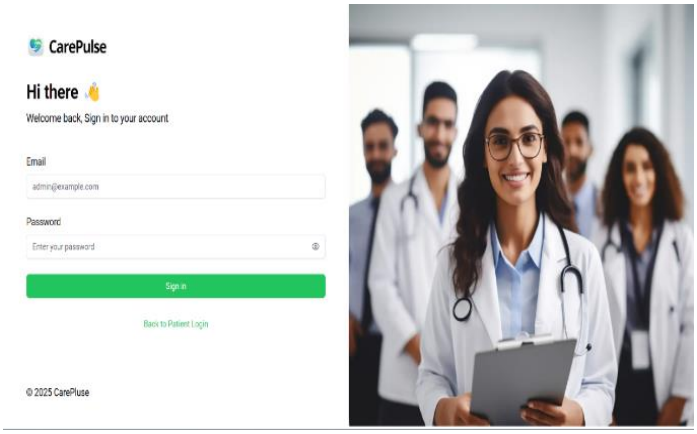

Figure 6: Staff Login Page

Users Dashboard

Once logged in, patients are redirected to the patient dashboard, where they can view upcoming appointments, view virtual card, access medical records and check billing details. Also, staffs are redirected to staff dashboard which gives hospital staffs. access to vital features including viewing, rejecting and accepting appointments, managing patient medical records, addressing patient complaints and managing patients bills.

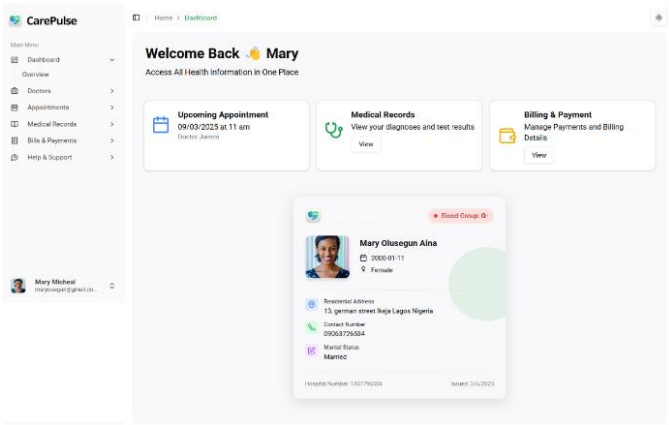

Figure 7: Patient Dashboard

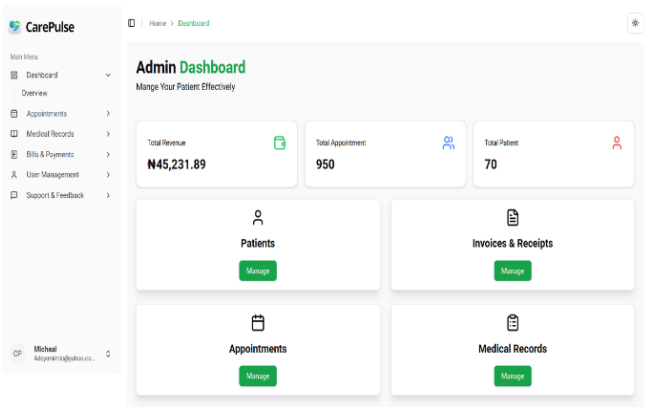

Figure 8: Staff Dashboard

Patient Appointment Page

The appointment booking page allows patients to schedule medical consultations by selecting a preferred doctor, date, available time slot, stating reason for appointment and contact details. This appointment history page allows patient to view booked appointment and previously booked appointment.

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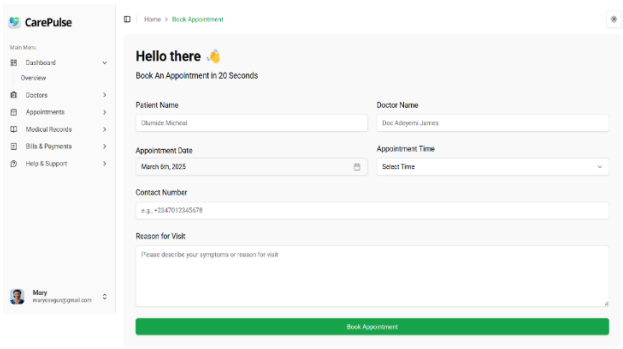

Figure 9: Appointment Booking Page

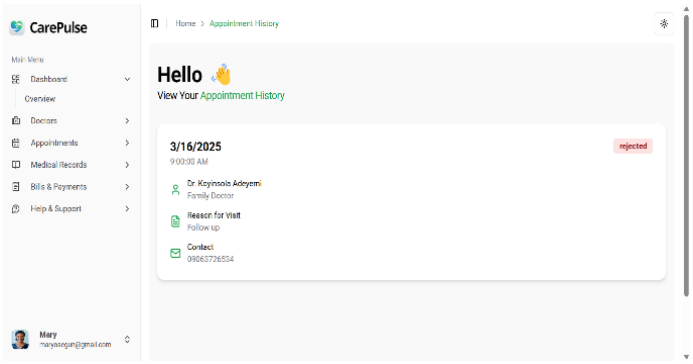

Figure 10: Appointment History Page

Staff Appointment Management Page

This page enables only Doctors and Receptionist to view scheduled appointments, where they can approve, reject, reschedule, or cancel appointments as needed. They can also view the full details of the Appointments.

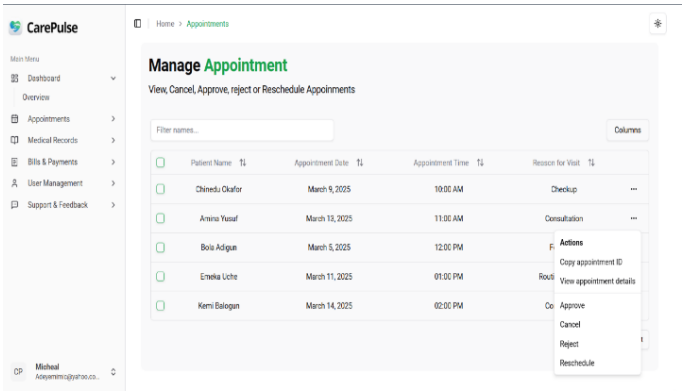

Figure 11: Appointment Management Page

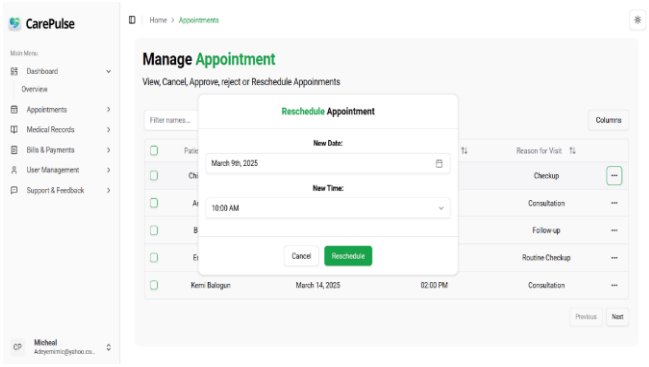

Figure 12: Reschedule Appointment Page.

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Medical Record Pages

Patients can access their medical records through the medical record viewing page. The patient can also export the medical record as a Portable Document Format (PDF). Doctors, on the other hand, utilize the medical record creation page to add to patient records.

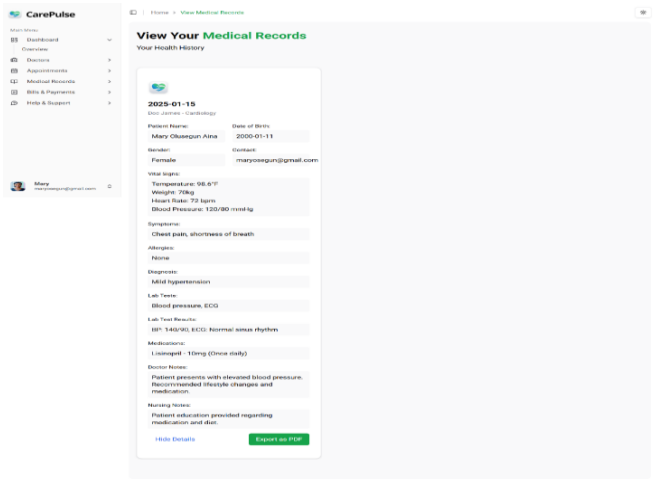

Figure 13: Medical Record Viewing Page.

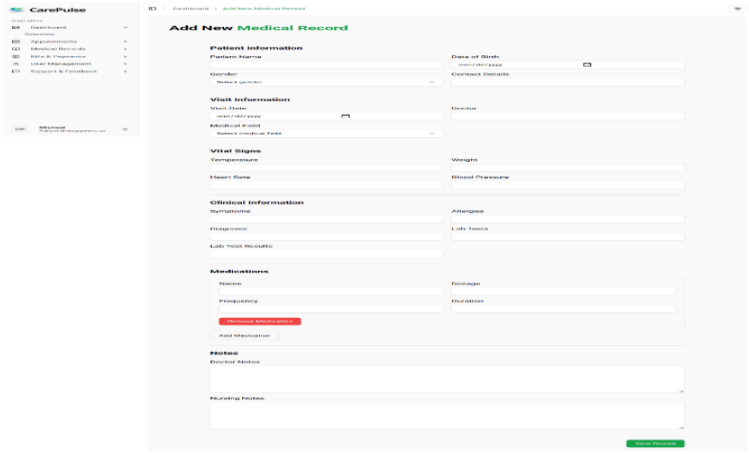

Figure 14: Medical Record Creation Page.

Billing Pages.

The PMS also includes a bill viewing page, where patients can view their invoices and receipts through the invoice and receipt viewing page. The invoices and receipt can also be exported as PDF. The invoice and receipt creation page allows the generation of new invoices and receipts, ensuring accurate financial documentation.

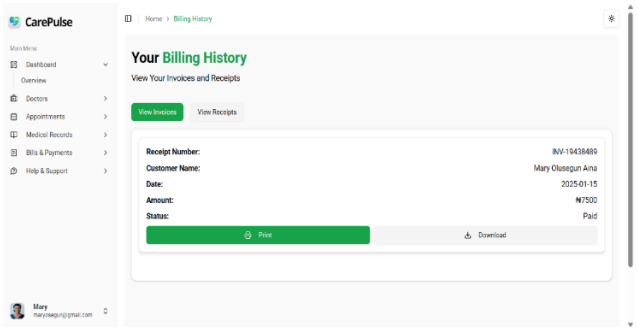

Figure 15: Invoice and Receipt Viewing Page

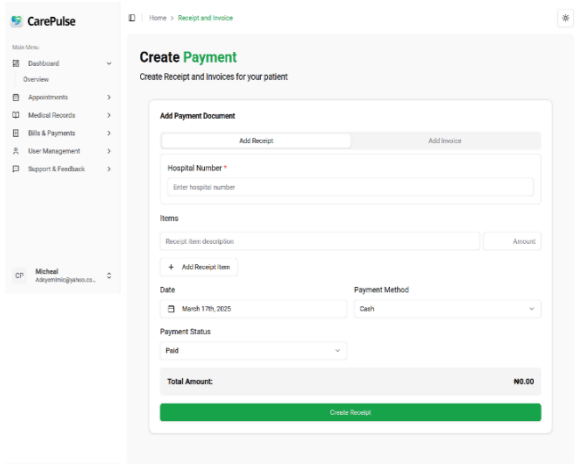

Figure 16: Invoice and Receipt Creation Page.

CONCLUSION

A web-based PMS was successfully developed in this study to alleviate operational inefficiencies in hospitals. The system enhances service delivery and data accuracy by automating medical records, billing, appointment scheduling, and patient registration. It was created with an incremental SDLC approach and contemporary web technologies, guaranteeing scalability, security, and usability. Encryption and role-based access improve data security. User satisfaction and system dependability were validated by testing. The PMS facilitates integrated healthcare delivery and lessens administrative burden. Better access to information empowers patients. The system satisfies essential hospital requirements while providing the groundwork for future improvements. It is advised to integrate mobile platforms, electronic payments and external health systems. This solution makes a significant contribution to the healthcare industry's digital revolution.

Ethical Approval

There was no direct experimentation or data collecting from humans or animals in this study; instead, it focused on the design and implementation of a software-based patient management system. Therefore, official ethical approval was not needed.

Conflict of Interest

Regarding the creation or reporting of this study, the authors state that they have no conflicts of interest.

Statement of Data Availability

The related author can provide the system source code and demonstration files upon reasonable request. During creation and testing, no actual patient data was used; all test data were created artificially but they still reflected real-world hospital operations.

REFERENCE

1. Smartsheet. (2019). How patient management software improves the health care experience. https://www.smartsheet.com/patient-management-software-systems
2. Patel, K., & Singh, N. (2020). Digital transformation in healthcare: Impacts and challenges. International Journal of Medical Informatics, 58(2), 22–30.
3. Rudin, R. S., Herman, P. M., & Vining, R. (2025). Addressing the “black hole” of low back pain care with clinical decision support: User-centered design and initial usability study. JMIR Formative Research. https://www.jmir.org

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue V May 2025

4. Gil-Hernández, E., Carrillo, I., Martín-Delgado, J., García-Torres, D., & Martínez, J. J. (2025). Development of a web-based intervention for middle managers in healthcare. JMIR Human Factors, 12(1), e67263. https://doi.org/10.2196/67263
5. Ciudad-Gutiérrez, P., Suárez-Casillas, P., Alfaro-Lara, E. R., Santos-Rubio, M. D., Santos-Ramos, B., & Guisado-Gil, A. B. (2025). ConciliaMed: An interactive mobile and web tool to reconcile chronic medications of patients undergoing elective surgery. BMJ Health & Care. https://www.ncbi.nlm.nih.gov
6. Basri, A. (2025). Queue system at Mandar community health center based on the web. Basri Baba Journal. Retrieved from PKP School
7. Huda, E., & Omaima, B. (2013). Towards healthcare data security in cloud computing. In IEEE Conference Publication. https://ieeexplore.ieee.org/abstract/document/6750223
8. Smith, J., & Anderson, R. (2019). Challenges of traditional medical record systems in modern healthcare. Journal of Health Informatics, 12(3), 45–55.
9. Gupta, S., & Roy, D. (2017). Scalability and security in hospital management systems. Journal of Healthcare Technologies, 11(5), 88–97.