



IMPROVING HEALTHCARE DELIVERY THROUGH A WEB-BASED MEDICAL APPOINTMENT AND EVALUATION MANAGEMENT MODEL

Adebayo Tunde Olumide

Department of Health Informatics, Faculty of Medical Sciences, University of Lagos, Nigeria

DOI: <https://doi.org/10.5281/zenodo.15828578>

Abstract: The healthcare sector is pivotal to individual well-being, where lapses in clinical services can lead to significant harm. This study emphasizes the necessity of placing patients at the forefront of healthcare delivery, which involves enhancing transparency regarding patient complaints and improving appointment scheduling systems. The research present the development of a Medical Appointment and Evaluation Management Model, leveraging modern technologies to address common challenges in traditional appointment methods, such as patient no-shows, inefficiencies, and communication breakdowns. The methodology adopted for this project is the Object-Oriented Analysis and Design Methodology (OOADM). The system is a web-based application designed for seamless appointment management, utilizing programming languages like HTML, CSS, and JavaScript for front-end development, while employing MySQL for secure health record management, and PHP for back-end development. The model resulted in a significant decrease in no-show rates. The Medical Appointment and Evaluation Management Model highlight the importance of technology integration in healthcare systems for improved patient satisfaction and operational performance. Future research should explore the long-term impacts of these systems and potential technological advancements.

Keywords: Medical Appointment Scheduling, Patient-Centered Care, Patient Satisfaction, No Show Rate, Healthcare Information Systems, Web-Based Application.

1.0 Introduction

The healthcare sector plays a critical role in individual well-being, with the medical practitioner-patient relationship at its core. Historically, this relationship has often overlooked patient voices, leading to neglect and dissatisfaction (Malashetty, 2012). Incorporating the patient's "Voice of the Lifeworld" alongside the "Voice of Medicine" can improve communication and trust in the physician-patient relationship (Khawaja, 2021). Central to this is the development of an effective appointment scheduling system.

The Medical Appointment and Evaluation Management Model aims to enhance patient experience by utilizing a web-based application for scheduling, thereby reducing waiting times and improving patient satisfaction. Given

the challenges posed by traditional methods, including high no-show rates and administrative inefficiencies, this research presents a timely solution to optimize healthcare delivery.

The current medical appointment scheduling systems in healthcare facilities are often inefficient and fragmented, leading to significant challenges such as increased patient waiting times, high rates of missed appointments (no-shows), and poor data management. Traditional methods, including stand-alone database systems and manual scheduling processes, which has fail to adequately address the needs of patients and medical practitioners, resulting in miscommunication, administrative inefficiencies, and compromised quality of care. This study aims to Design and Develop a Medical Appointment and Evaluation Management Model that addresses these issues by providing a centralized, user-friendly web-based application to enhance patient access, streamline scheduling, and improve overall healthcare delivery.

2.0 Literature Review

A thorough summary of the development, difficulties, and breakthroughs in medical appointment scheduling systems is given by the literature review. It highlights how important patient-centered care is and how technology can be used to improve healthcare delivery. The term "appointment" refers to arrangements for patient visits in healthcare. Appointments can be classified into three categories:

Static appointment scheduling- All decisions must be made prior to the beginning of a clinic session, which is the most common appointment system in healthcare. Dynamic appointment scheduling- which adapts to real-time data and;

Online appointment systems: which allow patients to book appointments via web platforms (Nazia & Sarda, 2014). This classification underscores the shift towards more flexible and responsive systems in healthcare.

Adebayo *et al.* (2014) highlighted the limitations of traditional appointment scheduling methods, relying on phone calls and paper records. They argued for the transition to online systems, which offer patients greater flexibility, improved access, and the ability to manage appointments conveniently.

Sherly (2016), found that an online arrangement fixing and booking framework is whereby a patient can straightforwardly approach the site or web application and interface with the specialist by the online programming framework. The patient can book their arrangement as per their helpful time. The patient can pick their preferred specialist and book an arrangement. Online arrangement, reservation, and planning framework can help the patients, the specialists, and the workplace staff by decreasing their time. It tends to be effortlessly performed by utilizing PCs and making arrangements as opposed to setting off to the hospital. Zhao *et al* (2017) shows that a web-based medical appointment system can provide like reduced no-show rates and improved patient satisfaction, but also face barriers related to cost, flexibility, and patient adoption.

Maryam (2018) demonstrates that clinical arrangements were made by attending the clinic and waiting in line for our turn. Once in a while it gets disturbing to the patients. The development of an online arrangement framework offered immortal and proficient admittance to medical care administrations. With this brilliant application, we can get crisis medical checkups. Here, individuals can pick specialists and in close by medical clinics. We can get this arrangement effectively through our mobiles, and with this savvy application, we can spare our time.

Marbough *et al* (2020) investigates patient no-shows and their detrimental effects on healthcare resource utilization, and recommends strategies like patient education and appointment reminders to reduce no-show rates.

Chiara *et al* (2018), also shows that a well-designed overbooking procedure can improve the management of medical centers, in terms of a significant increase of revenue, while keeping patient's waiting time and overtime under control. This was demonstrated by the results of a quasi-experiment (practical implementation of the strategy in the MR ward) and a simulation study (under different scenarios). Such positive results took advantage from a predictive model of no-show carefully designed around the medical center data

Su-Ying *et al.* (2022) investigated the application of behavioral economics in healthcare, focusing on how strategic reminders can enhance patient engagement and participation in scheduled appointments, ultimately leading to more consistent attendance.

Yu-Liang & David (2016) focused on developing predictive models for assessing patient no show probabilities. Their work highlights the importance of leveraging historical appointment data to inform scheduling practices, with the goal of minimizing the negative impact of no shows on service delivery.

The issue of appointment scheduling and overbooking in healthcare settings has been extensively researched. The majority of study focuses on session performance or the period between request and booked appointment. Their models take into account factors such as patient no-shows, balking behavior, and stochastic service timeliness.

Rivas .J. (2020) studies show that advance access scheduling in primary care aims to reduce appointment wait times and improve patient access and improve provider productivity. With the main objective of improving the services provided, promoting an increase in added value to the patient, there are several studies in the literature that aim to reduce the waiting time in different health services (Miao *et al.*, 2020). Literature reviews show the adoption of production system techniques adapted to health services, indicating a growing focus on operations management (Savva, 2019). In particular, using the Lean production system, several initiatives have been introduced in health services, with an emphasis on hospital areas such as the emergency department and operating room (Lima *et al.*, 2021). Although these studies demonstrate the good results of lean initiatives promoted in various health sectors, the importance of involving health professionals, including physicians, is emphasized as a fundamental factor for their long-term sustainability (Fournier *et al.*, 2021). Ashwini Bhugul (2019) developed a system that solves the problem of appointments by electively capturing all relevant information about the visitors, and that information is recorded in a centralized database server, which provides data management. Zety Marlia Zainal Abidin *et al* (2020) developed a system that was able to manage and monitor the visitors of an organization using face recognition as an authentication method. After the authentication and verification process, a valid visitor ID gets printed that contains a face image of the visitor, the date and time of visiting, and the name of the person to be visited. A face recognition visitor management system (FRVMS) is proposed to enhance the security of an organization from outsiders that are entering the building illegally for certain purposes, such as spying or stealing the organization's assets.

This literature review synthesizes existing research on appointment scheduling systems, revealing a clear trend towards more automated, patient-centered approaches facilitated by technology. It identifies gaps in current systems, particularly regarding the integration of patient preferences and the management of no-show rates. The insights gained from these studies provide a strong foundation for the development of a Medical Appointment and Evaluation Management Model, which aims to enhance efficiency, improve patient satisfaction, and adapt to the evolving landscape of healthcare services.

3.0 Materials and method

3.1 System Methodology

This study employs the Object-Oriented, Analysis, and Design Methodology. The method promises to reduce development time, reduce the time and resources required to maintain existing applications, increase code reuse, and provide a competitive advantage to organizations that use it. A quantitative and qualitative analysis was conducted to assess patient satisfaction with the present appointment booking system, and also to know how the existing system works before the design and the implementation of the newly proposed system. An important goal of object-oriented development is to change the nature of traditional software development from designing and writing models from scratch to building systems through the assembly of reusable software objects.

The reason for choosing OOAD is that it enables high-level programming and supports multiple models during development. Also it helps to investigate some of the problems of the existing system which include lack of reminder to doctors and patients of the appointment time and date. The methodology also promotes breaking down a system into smaller, manageable, and self-contained objects.

For this project, PHP has been selected as the primary programming language. PHP, which stands for "Hypertext Preprocessor," is a widely-used open-source scripting language specifically designed for web development. Its syntax is intuitive and resembles that of C and Perl, making it accessible to both new and experienced developers. One of the key advantages of PHP is its strong capability for server-side scripting, which allows for the creation of dynamic web pages that can interact with users in real-time. This feature is essential for our Medical Appointment and Evaluation Management Model, where user interactions such as scheduling appointments and accessing medical practitioners and records must be efficiently managed. Moreover, PHP boasts a rich ecosystem of frameworks and libraries that can accelerate the development process.

Frameworks like Laravel and Code-Igniter provide robust tools for building secure and scalable web applications, which align with our project's requirements for reliability and performance. Additionally, PHP is compatible with various database management systems, including MySQL, which we plan to use for our health record-keeping system. This compatibility streamlines the integration between the programming language and the database, enabling seamless data management and retrieval. In summary, the choice of PHP as the programming language for our Medical Appointment and Evaluation Management Model is driven by its ease of use, extensive community support, and robust capabilities for developing dynamic web applications.

a) JavaScript

JavaScript is simple to comprehend and pick up. Both users and developers will find the structure to be straightforward. Additionally, it is very doable to implement, saving web developers money when creating dynamic content. It is an "interpreted" language; it cuts down on the time needed for compilation in other programming languages like Java. Another client-side script is JavaScript, which accelerates program execution by eliminating the wait time for server connections. Data validation can be done within the browser itself rather than being forwarded to the server because JavaScript is client-side. The entire website does not need to be reloaded in the event of any discrepancy. Only the chosen area of the page is updated by the browser.

b) MySQL

MySQL is an open-source relational database management system that organizes data into one or more data tables in which data may relate to each other. It is a language that programmers use to create, modify, and extract data from relational databases, as well as control user access to the databases. It works with the operating system to implement a relational database in a computer's storage system, manages users, allows for network access, and facilitates testing database integrity and the creation of backups.

3.2. Architectural Framework of the Proposed System

The proposed system introduces a Medical Appointment and Evaluation Management Model that utilizes a web-based architecture, ensuring seamless integration, real-time data access, and improved patient engagement.

Components:

- **Web-Based User Interface:** A user-friendly interface was designed using HTML, CSS, and JavaScript, allowing patients to schedule, modify, and cancel appointments online. This empowers patients to manage their healthcare needs from anywhere.
- **Server-Side Logic:** The system was implemented using PHP to handle business logic, process appointment requests, and manage communication between the database and the user interface.

- **Database Management:** The system utilizes MySQL for robust data storage, ensuring secure and efficient management of patient records, appointment logs, and scheduling information.
- **Communication Module:** Automated communication (via email or SMS) for appointment confirmations and reminders, reducing no-show rates and facilitating better patient follow-up.
- **Cloud Integration:** The system may leverage cloud technologies to enable scalability, improving accessibility and data sharing among healthcare providers and practitioners.

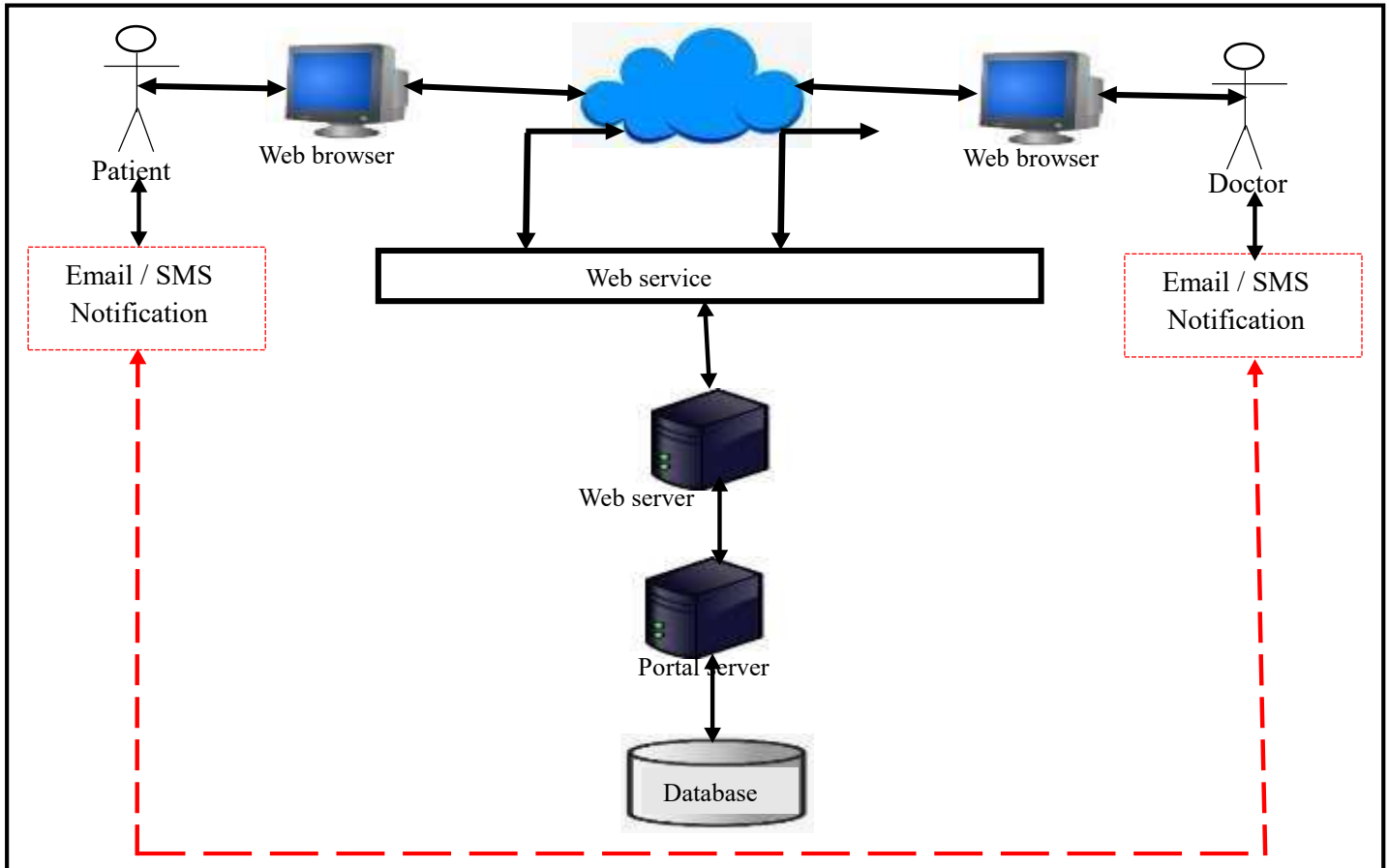


Figure 3.1: Architectural design of the proposed system

3.3. Benefits of the Proposed System

- **Enhanced Efficiency:** Reduces patient wait times and optimizes resource allocation through better scheduling algorithms.
- **Improved Data Integrity:** Digital records minimize the risk of data loss and inaccuracies associated with manual processes.
- **Patient-Centered Features:** The system allows for easy access to appointment scheduling and provides patients with choices regarding their healthcare providers and times.

3.4 System Specification

System Requirements involves hardware, i.e. the computer machine used in the development. It also includes the software, i.e. the program tools used in the development and deployment of the system.

3.4.1 Hardware requirements:

The minimum hardware requirements for the system are as follows:

1. 125 GB Hard Disk Drive.
2. Intel Core i3, 2.0GHz processor. Memory: 2GB-4GBRAM.

3.4.2. Software requirements:

The software requirements for the deployment of the system include the following:

- i. Operating System: Windows XP, Windows 7, Windows 8 and Windows 10 above versions of operating systems are all compatible for the deployment of the system.
- ii. IDE/Text Editor: Visual Studio code for editing.
- iii. Database: MySQL.
- iv. Application server: XAMPP, Node.js
- v. Browser: preferable Google Chrome or Mozilla Firefox.
- vi. Front-end: HTML5, CSS, and JavaScript.
- vii. Framework/APIs: Angular JS, React

3.5. Method implementation

The primary purpose of the system implementation is to establish a user-friendly and efficient web-based application for booking medical appointments, integrating patient information, and improving communication between healthcare providers and patients. The implementation aims to address current issues with traditional scheduling systems, such as high no-show rates and inefficient data administration.

1. Designing the Model for Appointment Booking:

- Front-End Development: A responsive and intuitive front-end interface was created using HTML, CSS, and JavaScript to allow patients to view available appointment slots, select their preferred time and date, and provide necessary information for booking.
- Back-End Development: PHP was used for server-side scripting, to handle the logic for processing appointment bookings, checking availability, and updating the database accordingly.
- Database Schema: A relational database schema was designed using MySQL to store patient information (e.g., name, contact details), practitioner details (e.g., name, specialty), appointment details (e.g., date, time), and availability schedules and thus, securely store patients and practitioners data, manage appointment schedules, and facilitate efficient retrieval and updating of information.
- Appointment Scheduling Algorithm: An algorithm in PHP was implemented to automatically schedule appointments by considering patient preferences (e.g., preferred time of day) and practitioner availability, while minimizing scheduling conflicts.

2. Proposed System Algorithm:

```

START {
  INPUT:      register
             INPUT:      Login using patient id
  INPUT: Upload medical history
  INPUT: select Doctor
             IF      (doctor, time and day are free) THEN:
                   Book appointment  else
             return to available doctor
             PROCESS

```

```

Else {
  Return to login
} Stop

```

3. Flow Chart of the Proposed System:

Information means processed data and it is vital in every organization. The diagram below will tell us the actual logic behind the store allocation system.

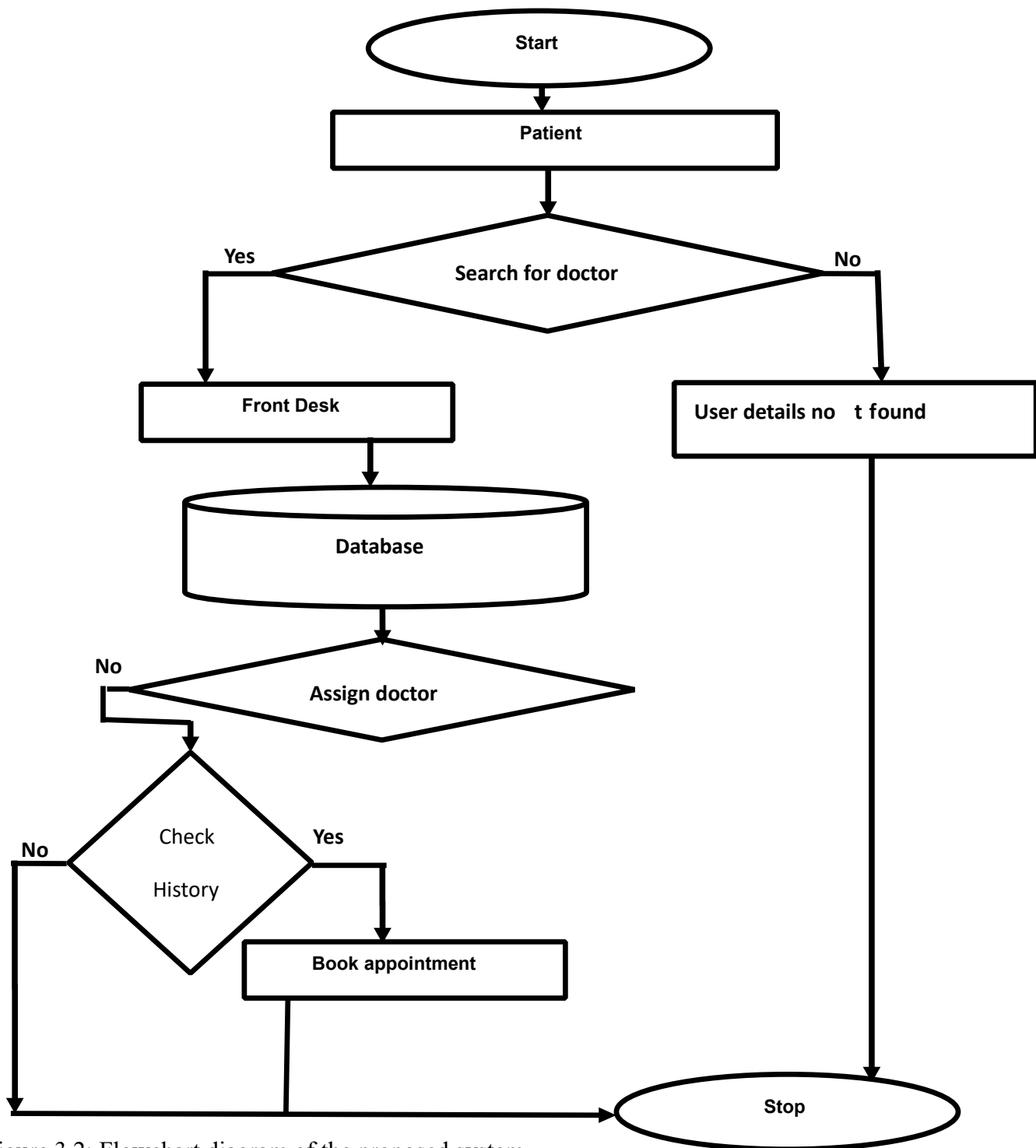


Figure 3.2: Flowchart diagram of the proposed system

3.6. Method Validation

We tested the implemented software for the following purposes;

1. **Functionality Testing:** We carried functionality testing on the implemented system to check if the initial build works as per its system design and analysis. This includes form validation, cookie and session testing, HTML and CSS validation, and database connection check-up.
2. **Compatibility and Performance Testing:** In compatibility testing, we check whether or not our web design is compatible with a variety of browsers and devices. This includes browser and OS compatibility testing, along with mobile browsing and printing options testing.

Our implemented system looks great in all browsers and compatible with all leading operating systems. And lastly, we carried out performance testing and our implemented system is scalable and capable to withstand multiple users.

3. **System Integration and Testing:** To integrate the front-end and back-end components, we followed a modular approach, ensuring that the components could communicate seamlessly. We established APIs and endpoints for data exchange between the front-end (HTML, CSS, JavaScript) and back-end (PHP) components. We conducted rigorous testing to verify the integration, ensuring that data flows correctly and functionalities are synchronized. Any issues or conflicts were resolved by debugging and refining the integration code.

Thorough testing of the system was performed to identify and rectify any bugs or issues. We conducted unit testing, integration testing, and system testing to ensure the stability, reliability, and functionality of the entire system. Test cases were designed to cover different scenarios, edge cases, and user interactions. Bugs and issues were logged, prioritized, and fixed in an iterative manner. This iterative testing process allowed us to enhance the quality of the system and ensure a smooth user experience.

4. **User Acceptance Testing:** User Acceptance Testing (UAT) was conducted to validate the system's usability, performance, and accuracy. We involved stakeholders, including hospital administrators, doctors, and patients, in the testing process. Test scenarios were designed to simulate real-world usage, and stakeholders provided feedback on the system's user interface, ease of use, responsiveness, and overall satisfaction. Their input was crucial in identifying any usability issues, performance bottlenecks, or discrepancies between expected and actual system behavior. Based on the feedback and testing results, necessary improvements were implemented. We carefully analyzed the feedback received from stakeholders and the findings from testing. Identified issues were categorized, and a priority list was created to address critical and high impact improvements first. The feedback was valuable in guiding the implementation of enhancements, bug fixes, and optimizations. Regular updates and iterations were made to ensure that the system met the expectations and requirements of the stakeholders and provided a seamless user experience.

3.7. Tools Required For Adequate Method Validation

- i. **XAMPP:** XAMPP is an open-source, cross-platform web server developed by Apache Friends, consisting of Apache HTTP Server, MariaDB database, PHP, and Perl script interpreters, making it easy to set up and deploy locally.
- ii. **Mozilla Firefox:** Mozilla Firefox, a free, open-source web browser founded in 2002, promotes privacy, security, and personalization, offering a variety of add-ons and performance-optimized features.
- iii. **Google Chrome:** Google Chrome, an open-source web browser, was first released in 2008 and quickly gained popularity due to its speed, simplicity, and wide compatibility, built on the chromium engine.

3.7. Evaluation of the System on the Problem Domain

The system was tested for functionality, performance, user feedback, and impact to ensure accurate appointment scheduling, efficient multi-user handling, and increased patient happiness. The system's influence on scheduling efficiency, wait time reduction, and improved access to medical treatment increased overall productivity.

4.0 Result

One of the notable achievements of this system is the seamless and user-friendly interface designed, and a reminder feature using HTML, CSS, and JavaScript. The multi-step booking modal created with interactivity using JavaScript provided a smooth and intuitive user experience. The system's frontend design received positive feedback from users, with patients finding it easy to navigate and healthcare professionals appreciating its simplicity.

4.1 Sample Output

- i. Main Menu Design: The main menu carries a high-level design of the system. It is the control center that loads all other modules. The main menu also called the home page for this system is developed as a Web application, using the language of the web. This system is made up of more than one interface which is loaded from the home page to bring about its full functionality.
- ii. Home Page: This page showcases the background of the system and contains other pages.
- iii. Registration page: The registration page is a user interface where new users can create an account to access the system. This page captures essential details such as the user's name, contact information, email, password, and role-specific information (eg. patient, doctor or administrator).
- iv. Login: This is the interface that the admin, doctors, and patients makes use of to access their profile.
- v. Contact Us: Contact provides contact information about the system. It shows its physical address, electronic address (e-mail), phone numbers. The incorporation of reminder is intended to help mitigate the issue of patient no-shows by proactively notifying patients of their upcoming appointments.

4.2 System Screenshot

The system screenshot present various figures of the system outputs;

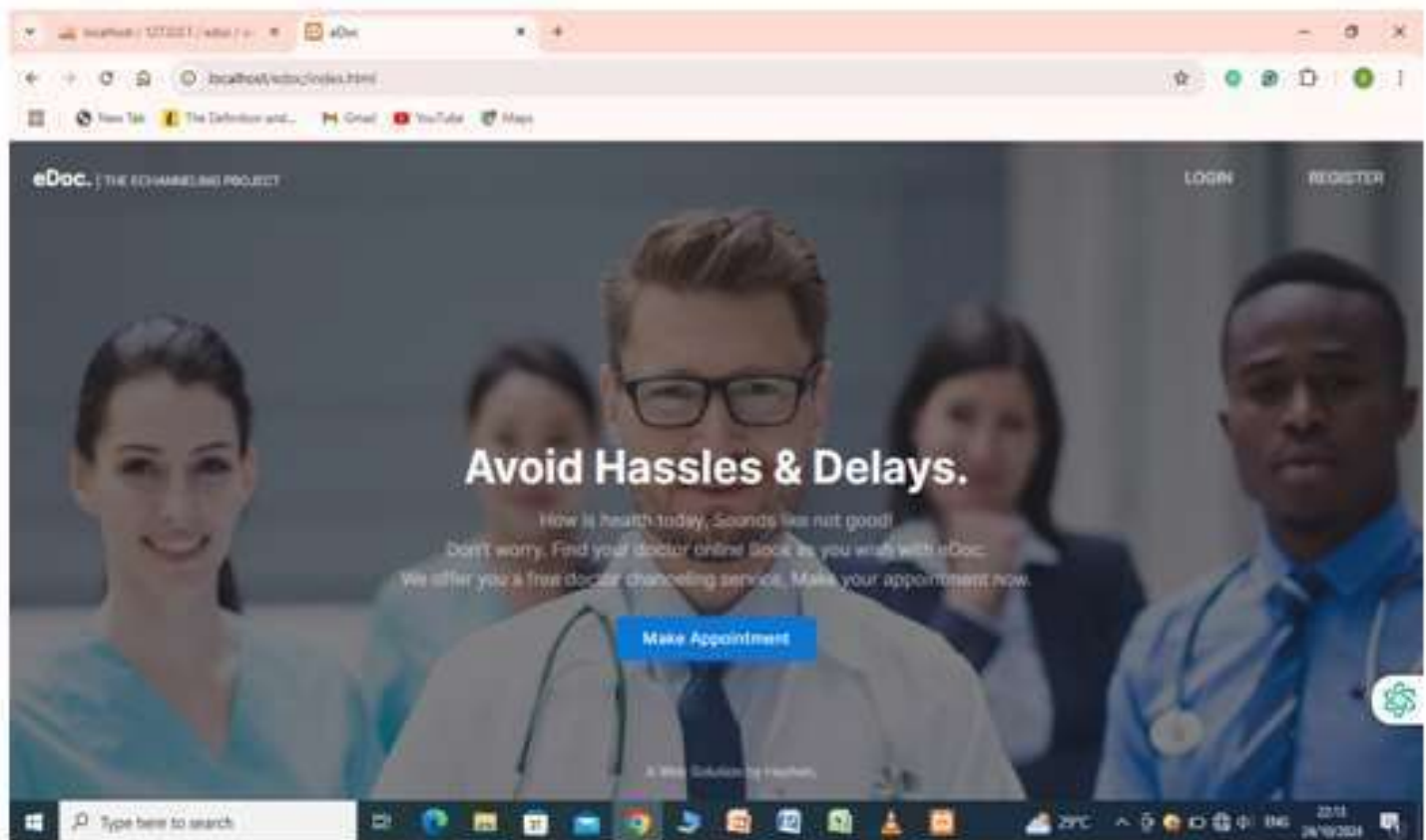


Figure 4.1: Main Menu/Home Page

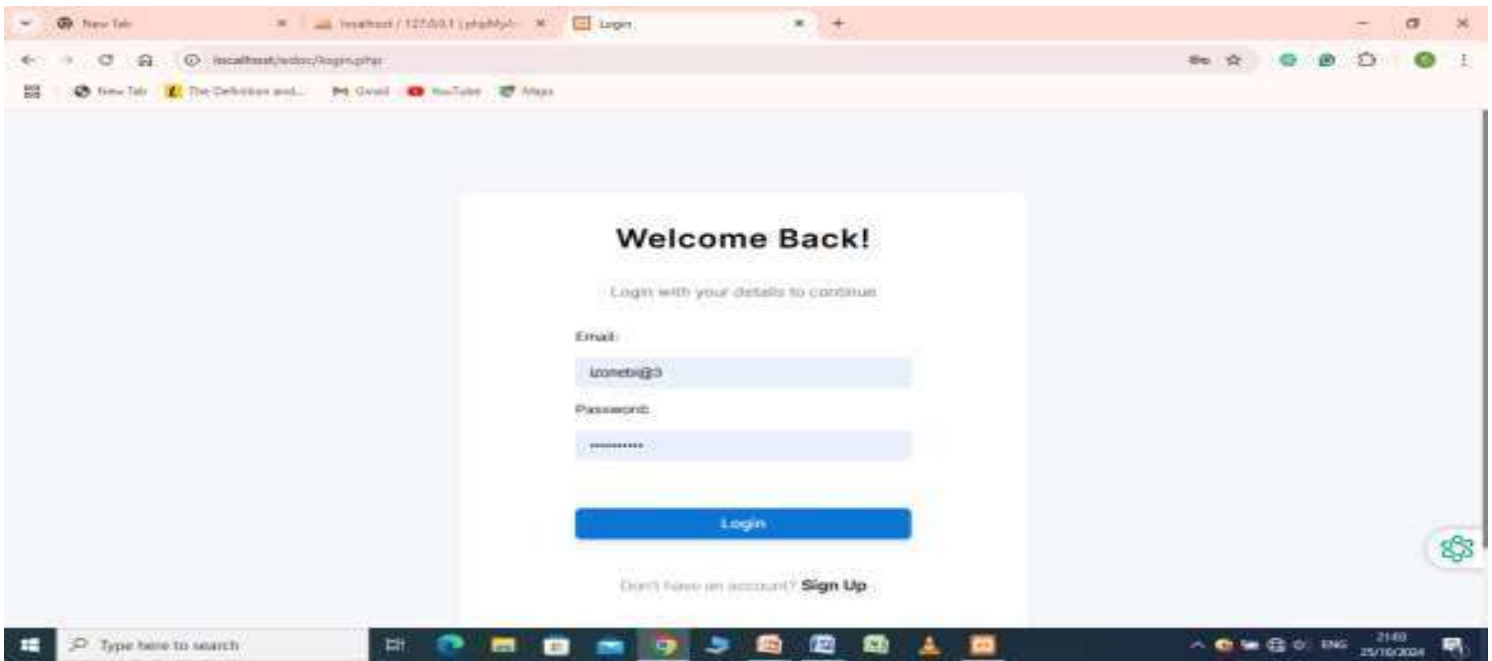


Figure 4.2: Login Page

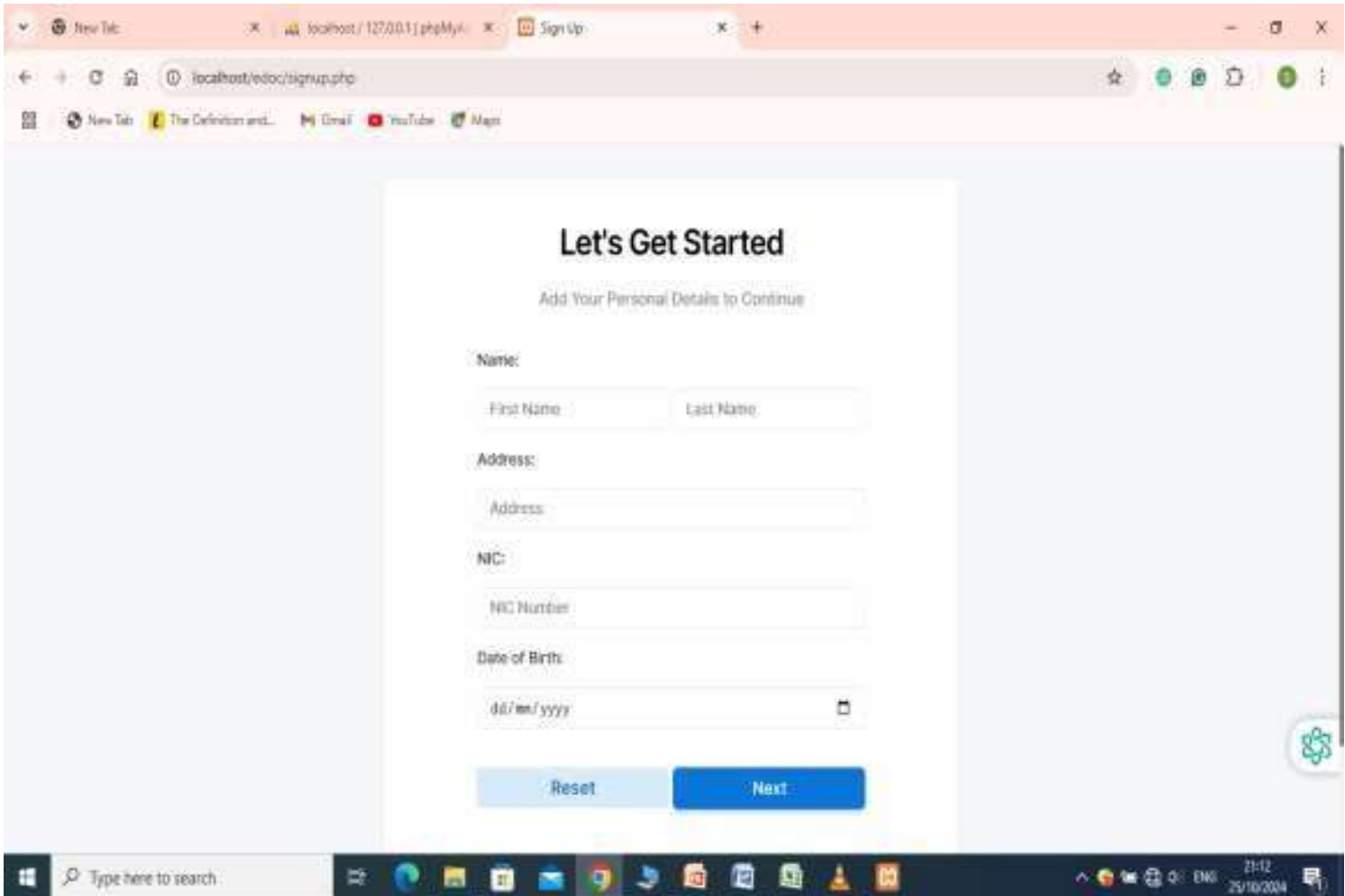


Figure 4.3: Sign Up/ User Registration Page

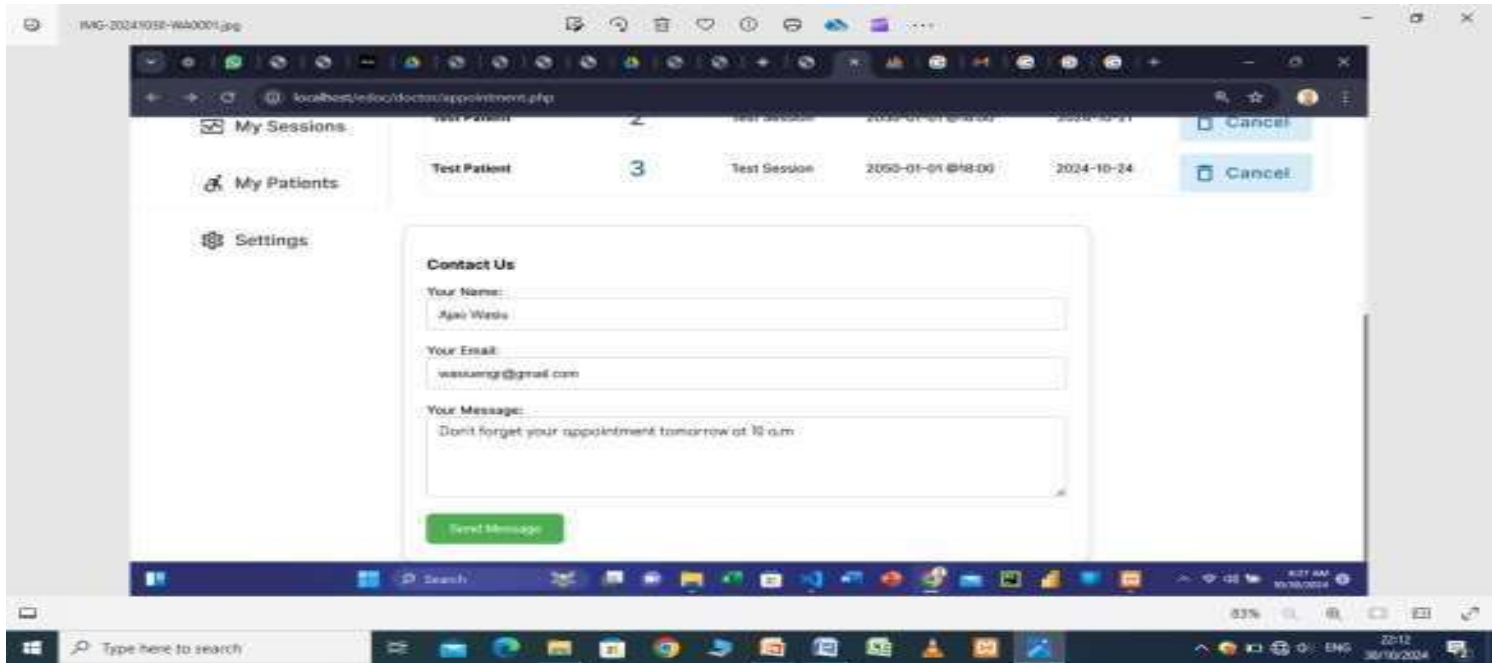


Figure 4.4: Contact Us Page

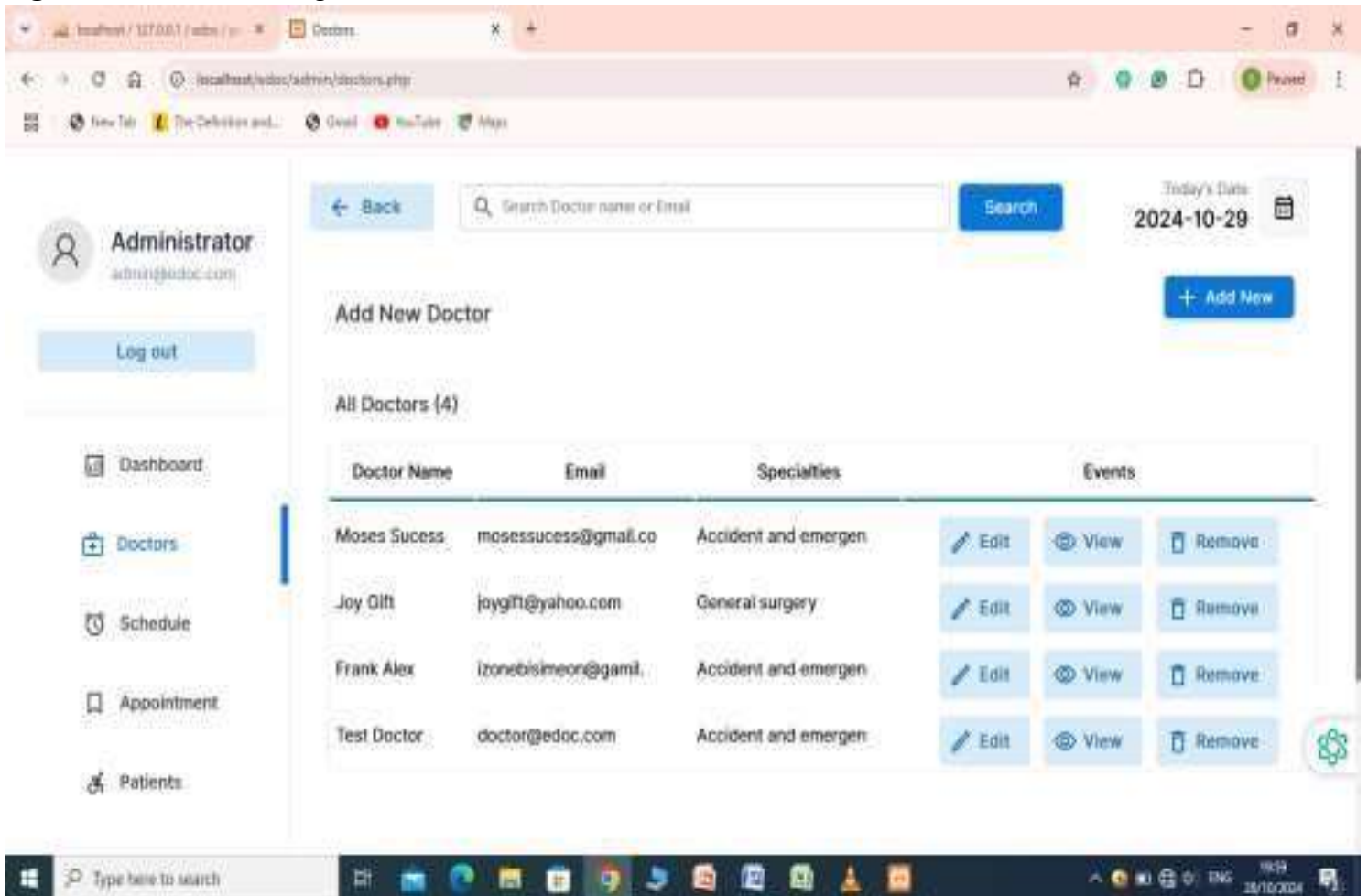


Figure 4.5: Admin page

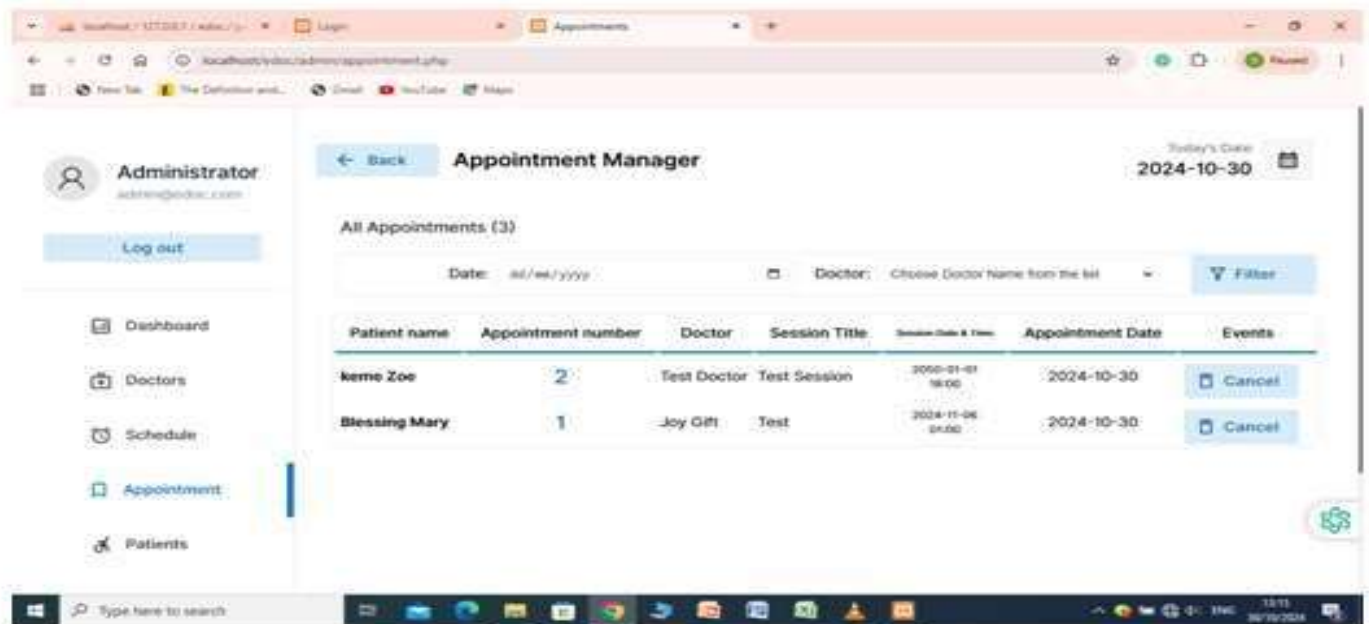


Figure 4.6: List of Booked Appointment

5.0 Conclusion

Doctor appointment systems are essential in modern healthcare because they allow patients to schedule appointments with healthcare professionals effectively. They shorten wait times, improve scheduling processes, and reduce administrative hassles.

A well-designed website for keeping patient information is critical for enhancing healthcare outcomes, patient happiness, and process efficiency. A user-friendly interface, Smartphone compatibility, and configurable booking options enable patients to arrange appointments from anywhere, eliminating wait times and frustration. Implementing a doctor appointment system online can improve patient experiences and overall healthcare quality. The development and implementation of the Medical Appointment and Evaluation

Management Model illustrate the critical need for technology integration in healthcare systems. By prioritizing patient-centered approaches and enhancing appointment scheduling efficiency, healthcare providers can significantly improve patient satisfaction and operational performance. The findings of this study contribute valuable insights for healthcare administrators seeking to modernize their appointment systems and better meet the needs of their patients. Future research should continue to explore the long-term impacts of such systems on healthcare delivery and patient outcomes, as well as the potential for further technological advancements in the sector. Future work includes integrating telemedicine into doctor appointments, gathering patient feedback to improve bookings, and integrating wearable devices for real-time health metrics. These suggestions aim to provide a comprehensive, convenient solution for patients and cater to their specific needs.

References

- Adebayo, A., Agbaje, M., & Adebisi, A. (2014). Dependable online appointment booking system for NHIS outpatient in Nigerian teaching hospitals. *International Journal of Computer Science & Information Technology*, 6(4).
- Ashwini, B. (2019). Visiting monitoring system. *International Journal of Engineering and Technology*, 8(5), 2278-0181.
- Chiara, P., Salvatore, D., Gallo, G., & Cipollini, F. (2018). Using overbooking to manage no-shows in an Italian healthcare center. *BMC Health Services Research*, 18(1). <https://doi.org/10.1186/s12913-018-2979-z>

- Fournier, P., Jobin, M. H., & Lapointe, L. (2021). Lean implementation in healthcare. *Production Planning and Control*, 34(6), 493-505. <https://doi.org/10.1080/09537287.2021.1938730>
- Lima, R. M., Dinis-Carvalho, J., Souza, T., Vieira, E., & Gonçalves, B. (2021). Implementation of lean in healthcare environments: An update of systematic reviews. *International Journal of Lean Six Sigma*, 12(1), 2040-4166.
- Marbough, D., Khaled, I., Al Shariqiti, K., & Al Taminimi, M. (2020). Evaluating the impact of patient no-show on service quality. *Risk Management and Healthcare Policy*, 13, 509-517.
- Maryam, T. (2018). Online polyclinic appointment and database management system (Master's thesis). 43 pages, appendices 1 page.
- Miao, R., Lu, Y., Cao, Y., & Du, Q. (2020). The high-performance work system, employee voice, and innovative behavior: The moderating role of psychological safety. *International Journal of Environmental Research and Public Health*, 17(14), 1150. <https://doi.org/10.3390/ijerph17041150>
- Nazia, & Sarda. (2014). Online appointment scheduling system for hospitals—An analytical study. *International Journal of Innovations in Engineering and Technology*, 4(1).
- Rivas, J. (2020). Advanced access scheduling in primary care: A synthesis of evidence. *Journal of Healthcare Management*. <https://doi.org/10.1097/JHM-D-19-0004>
- Savva, C., & Keskinocak, P. (2019). A review of the healthcare management (modeling) literature. *Manufacturing and Service Operations Management*, 22(1), 59-72. <https://doi.org/10.1287/msom.2019.0784>
- Sherly, I. (2016). Online appointment reservation and scheduling for healthcare: A detailed study. *International Journal of Innovative Research in Computer and Communication Engineering*, 4(2).
- Su-Ying, L., Stults, C., Jones, V. G., Huang, Q., Sutton, J., Tennyson, G., & Albert, S. C. (2022). The effects of behavioral economics-based nudge on online scheduling and appointment completion: Observational study. *JMIR Human Factors*, 9(1), 1. <https://doi.org/10.2196/34090>
- Zety, M. Z., A., Satari, B., & Rahman, N. A. (2020). Face recognition for security efficiency in managing and monitoring visitors of an organization. *International Symposium on Biometrics and Security Technology (ISBAST)*, IEEE. <https://doi.org/10.1109/ISBAST.2014.7013101>