HEALTHWAVE EHR SYSTEM

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Abstract. The HealthWave Electronic Health Record (EHR) system represents a significant advancement in digital healthcare technology. This paper delves into the comprehensive aspects of the HealthWave EHR system, including its design, technical architecture, and operational features. We explore the system's impact on patient engagement and communication, highlighting its user-friendly interface, robust data management capabilities, and integration of advanced technologies. An in-depth user manual style guide is provided to assist users in navigating the system efficiently. Additionally, the paper evaluates the system's effectiveness through a System Usability Scale (SUS) questionnaire, providing insights into user satisfaction and areas for improvement. This study aims to underscore the critical role of EHR systems in modern healthcare and the potential of HealthWave to enhance patient care and streamline healthcare processes.

Keywords: Electronic Health Records · EHR System Design · Patient-Centered Care · Digital Healthcare · Patient Data Management · System Usability.

1 Introduction

1.1 What's an Electronic Health Records?

Electronic Health Records (EHR) represent a digital evolution in the healthcare industry, transforming the traditional paper-based system into an integrated and comprehensive electronic platform. An EHR is a digital version of a patient's paper chart, containing their medical history, diagnoses, medications, treatment plans, immunization dates, allergies, radiology images, and laboratory test results. This information is accessible to authorized healthcare providers, ensuring seamless and efficient healthcare delivery[1].

1.2 Importance of EHR

The integration of Electronic Health Records (EHR) systems is now essential in contemporary healthcare for several vital reasons. Primarily, EHRs significantly elevate the quality of patient care. They achieve this by ensuring health information is not only precise but also current and readily accessible, thereby enhancing clinical judgment and lowering the risk of medical errors [2]. Furthermore, EHRs

foster improved communication and collaboration among healthcare professionals, which is pivotal for effective patient treatment. The implementation of EHRs also brings about operational efficiency, leading to cost reductions for medical facilities. This efficiency is due to streamlined administrative procedures, lessened paperwork, and the avoidance of redundant tests. Beyond these practical advantages, EHRs also play a critical role in advancing medical research and public health efforts. They do this by providing a means to anonymize and compile patient data for comprehensive analysis [3, 4].

1.3 Usage of EHR

EHRs (Electronic Health Records) are employed by healthcare professionals as digital tools to record, preserve, and organize patient health data. These systems enable the input of new information, the monitoring of health changes over time, and offer access to a patient's entire health history through a unified platform. EHRs are instrumental in aiding clinical decision-making, as they provide critical alerts regarding possible complications, drug interactions, and suggestions for preventive healthcare measures. For patients, EHRs offer substantial benefits. They allow individuals to view their health records, enabling easier communication with their healthcare providers and fostering an active role in managing their health and treatment plans [2, 3].

1.4 Development and Brief History of EHR

The development of Electronic Health Records (EHRs) has been a progressive journey spanning several decades, deeply intertwined with technological advancements and policy shifts in healthcare.

In the early days, around the 1960s and 1970s, the focus was on creating standalone systems for specific healthcare functions like billing or laboratory results. The Regenstrief Institute, for example, was pivotal in developing one of the first iterations of what we now recognize as EHRs. This system aimed to tackle the challenge of creating a comprehensive database that could link healthcare organizations, disciplines, and professions. However, widespread adoption was initially limited due to factors such as the cost of equipment and the absence of demonstrable efficacy [5].

The 1990s marked a significant transition period, with the internet's emergence catalyzing the move towards digital medical records. Healthcare gradually began to embrace technology for record-keeping purposes, and by this time, EHRs were increasingly being used in academic medical facilities. This period laid the groundwork for what was to become the modern EHR system, integrating features like patient data interchange for claims processing and document capture of medical histories [6, 7].

A major catalyst for the widespread adoption of EHRs was the Health Information Technology for Economic and Clinical Health (HITECH) Act in the United States, enacted in 2009. This legislation provided financial incentives for healthcare organizations to implement EHR systems, significantly increasing

their adoption globally. By 2015, the adoption of EHRs had notably increased, with a majority of hospitals and physician practices using these systems [7].

Today, EHRs continue to evolve, integrating advanced features like interoperability, which allows for seamless information sharing among healthcare systems, and incorporating technologies like artificial intelligence. These advancements are aimed at enhancing healthcare delivery, improving patient outcomes, and contributing to the overall efficiency of the healthcare system [8].

As a team of students, our development of an EHR system as part of a course study represents a continuation of this ongoing evolution in healthcare technology. It's a field that has grown from basic digital record-keeping to sophisticated systems capable of improving patient care and facilitating global healthcare management.

1.5 Impact on Patient Engagement and Communication:

EHRs (Electronic Health Records) have significantly enhanced patient engagement and communication in healthcare. A key feature that facilitates this is the patient portal integrated into many EHR systems. These portals provide patients with convenient access to their medical histories, test results, and medication lists. They often include functionalities for scheduling appointments and communicating directly with healthcare providers, which greatly improves patient engagement.

The implementation of EHRs has empowered patients to be more involved in their care by providing access to their health information. This transparency and ease of access can lead to better patient outcomes, as patients become more informed and actively participate in their healthcare decisions. For instance, a study exploring the use of a second screen in exam rooms, mirroring the clinician's EHR screen, showed positive impacts on patient education, engagement, and trust [9].

However, while EHRs have the potential to enhance patient-provider communication, there are challenges. Some studies have shown that EHRs can disrupt the collection of psychosocial and emotional information, which is essential for building supportive, healing relationships. Therefore, a more rigorous examination of EHR impacts on communication functions and their influences on patient outcomes is necessary for achieving truly patient-centred care [10].

Moreover, the way healthcare providers interact with EHRs during patient encounters matters. Dr. Lee's research found that patients generally view EHRs positively, especially when their primary care doctors can see notes from other team members, thereby improving care. This led to the development of best practices for using EHRs to enhance patient-centred care and communication. These include engaging the patient directly during the first minute of the encounter, creating a 'triangle of trust' where both the physician and patient can view the EHR, and turning away from the EHR screen when discussing sensitive topics [11].

Overall, EHRs are key to engaging patients, providing access to their medical records, and ensuring participatory healthcare. The advancement in technology,

including interoperability between different EHR systems, plays a critical role in enhancing patient engagement and satisfaction. It's essential for healthcare providers to communicate electronically effectively and to leverage the advanced features of EHR systems to maintain patient engagement and satisfaction.

2 Website Design and Technical Architecture

2.1 Website Design

The HealthWave EHR system is designed with a user-centric approach, utilizing HTML5, Bootstrap 5, and CSS. This combination ensures a contemporary and flexible user interface that's easy to navigate. The layout is straightforward and optimized for various devices, a critical factor in healthcare settings. With its organized structure and calming colour palette, the system is conducive to efficiency in a healthcare environment.

On the functionality side, the system integrates PHPMailer for email confirmations and secure token generation, enhancing communication and security within the platform. The patient forms in the system have been thoughtfully developed to include input data fields, radio buttons, and checkboxes, allowing for comprehensive data collection for both creating and updating patient records.

A significant emphasis is placed on security, particularly for user access. The system features an auto-generation function for strong passwords when new doctors register, bolstering security against unauthorized access.

Moreover, the system's interface is carefully designed to ensure user-friendliness. All static pages are efficiently organized within a navigation bar on the homepage. This design not only simplifies the homepage layout but also provides streamlined access to various sections without overwhelming the user.

2.2 Technical Architecture

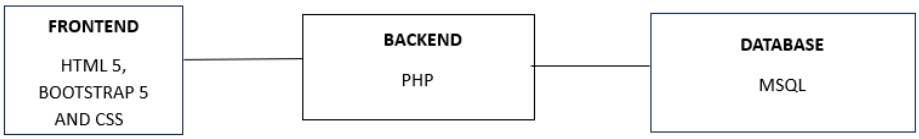


Fig. 1. Architectural Overview of the HealthWave EHR System, illustrating the integration between the Frontend, Backend, and Database components.

The architecture of the HealthWave EHR System, as depicted in fig 1, is engineered for robust data handling and operational efficiency. The flow begins at the frontend where users interact with the system through a web interface, proceeding to decision-making processes that guide whether a user needs to log in or register. After authentication, the system transitions users to the patient

dashboard. Here, actions such as patient registration, record updates, profile viewing, or record deletion are managed through the backend PHP logic, interacting seamlessly with the MySQL database to retrieve or store information securely. The process is designed to ensure a smooth and logical sequence of operations, culminating in a secure logout to maintain data confidentiality.

2.3 Core Technologies and Database Integration:

The interface of the HealthWave EHR system is built on HTML5, ensuring a structured and compliant web presence. Bootstrap 5 is utilized to render the layout responsive, allowing the system to function seamlessly across different devices — a critical feature for healthcare providers who may switch between desktops and mobile devices. CSS is employed to apply the visual design, ensuring a professional and consistent look across the platform.

For visual cues and interactive elements, the system incorporates Font Awesome icons. These icons indicate actionable items and navigation aids within the application, such as updating patient records or accessing different sections of the patient dashboard. They are chosen for their clarity and quick loading times, which is essential for efficient use within a busy healthcare environment.

JavaScript is implemented to provide dynamic client-side features. It is responsible for validating form entries in real time, enabling asynchronous data updates without needing to refresh the page, and managing user interactions with the dashboard effectively. This results in a more responsive user experience, reducing the time medical staff spend on administrative tasks.

On the backend, PHP is tasked with server-side logic, including securing user sessions and processing patient data interactions. It works in conjunction with the MySQL database, which stores all patient information securely. MySQL's robust structure is designed to handle complex queries quickly, ensuring data is always up-to-date and accessible when needed by the medical staff.

3 EHR Information System (User Manual Style)

The flowchart in fig 2 provides a step-by-step visual guide to the HealthWave EHR System's user interface. Starting from the "HOME PAGE," users are presented with the initial decision point asking "ARE YOU REGISTERED?" This determines the path users will take:

1. For registered users, the flowchart directs them to "SIGN IN TO" the system using their credentials. Upon successful login, users are taken to the "PATIENT DASHBOARD."

2. If the user is not registered, they are guided to "REGISTER AS NEW DOCTOR," which then leads to the login process after successful registration.

The "PATIENT DASHBOARD" serves as the central hub for all patient management activities. Here, users can: - "REGISTER" new patients, - "UPDATE" existing patient details, - "VIEW" patient profiles, and - "DELETE" patient records as needed.

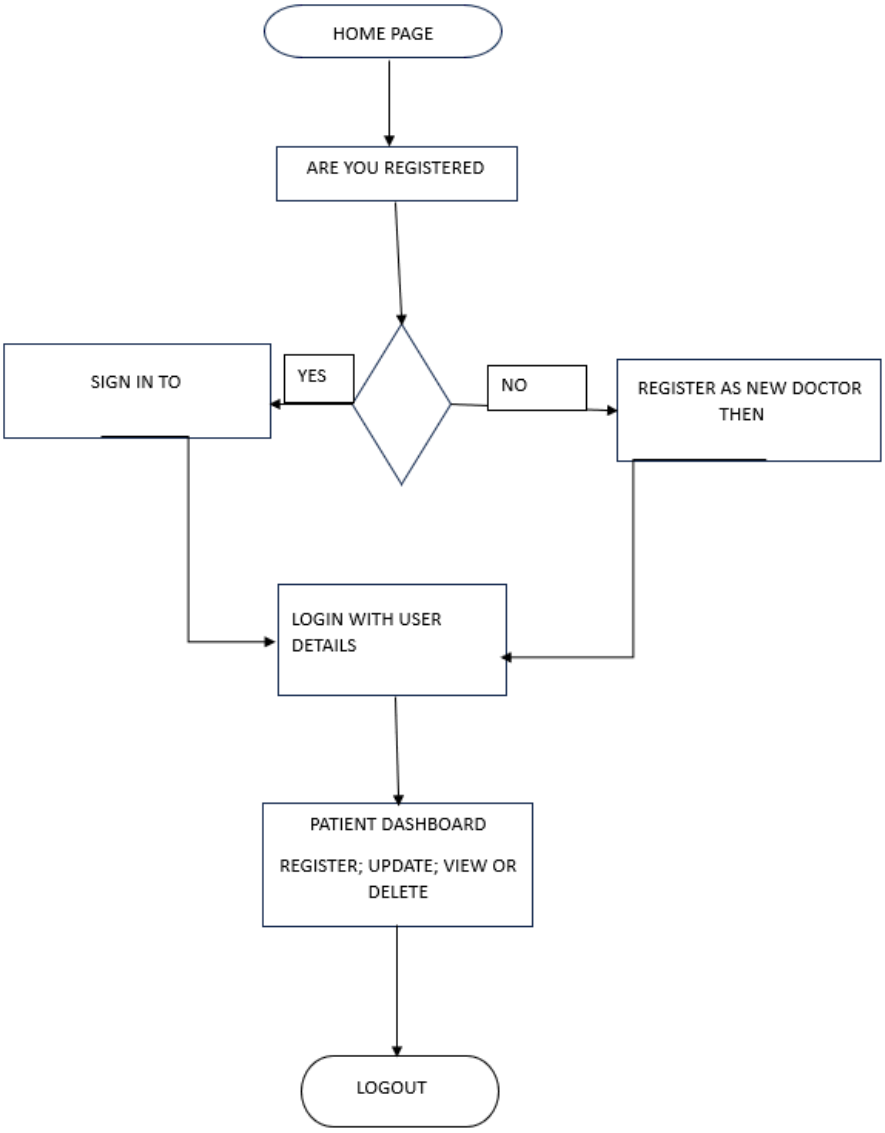


Fig. 2. User Interaction Flowchart for the HealthWave EHR System, detailing the steps from the home page access to logout, including decision points for user registration and patient management functionalities.

Once the desired actions are completed, the user can securely "LOGOUT" of the system, ensuring that all patient information remains confidential and the session is properly closed.

User Authentication and Registration: The registration page, developed with PHP and HTML, is designed for security and ease of use, featuring:

- Access Control: Restricts access to the registration form for logged-in users.
- Form Validation: Basic validation checks to capture accurate user details.
- Secure Data Handling: Employs MD5 for password hashing, with plans to transition to bcrypt.
- User Interaction: Confirmation emails are sent via PHPMailer, and a password suggestion tool is provided for enhanced user support.

Doctor and Patient Functionalities: The system offers comprehensive functionalities tailored for both doctors and patients, ensuring a smooth digital interaction. Upon accessing the "HOME PAGE," doctors are prompted to log in or register as in fig 3. Post-authentication, they are directed to a dashboard where they can manage patient information effectively as seen in fig 4.

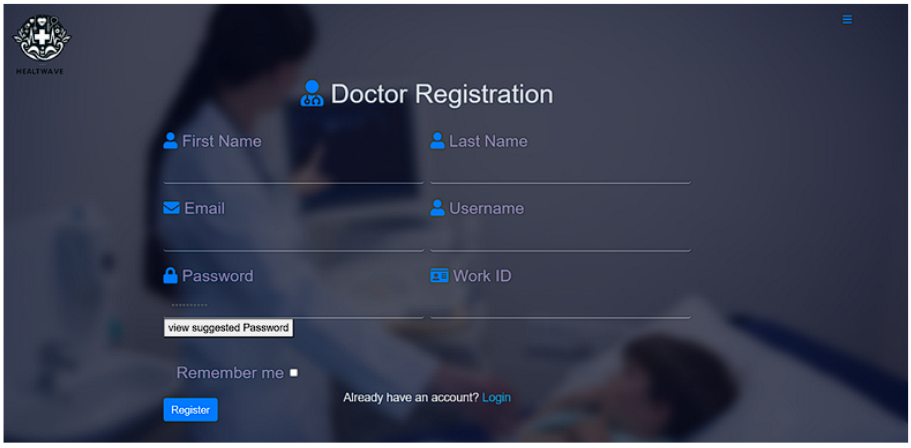
Key features include:

- Patient Registration: This feature enables doctors to effortlessly register new patients in the system. Key details such as the patient's name, age, gender, address, and contact information are easily inputted, as demonstrated in Fig. 5.
- Patient Record Management: This functionality facilitates the updating of existing patient records. As illustrated in Fig. 6, it allows for modifications to patient information to ensure records remain current and accurate.
- Patient Profile Access: Through this feature, doctors can access comprehensive patient profiles. These profiles encompass a patient's historical medical data, ongoing treatment plans, and scheduled future appointments, providing a holistic view as depicted in Fig. 7.
- Secure Logout: A secure logout mechanism ensures that the session is properly terminated, safeguarding against unauthorized access.

Operational Features and Deletion Protocol: The operational features of our system play a pivotal role in enhancing the security and efficiency of managing patient records. These features allow for secure updates, ensuring that any alterations to patient data are conducted in a controlled and traceable manner.

The deletion protocol upholds data integrity and complies with stringent security standards. Before any data deletion occurs, the system conducts a verification process to ensure stable and secure database connections. This is followed by validation of patient IDs, an essential step to prevent accidental deletion of records. Only after these checks are the DELETE statements executed, carefully and precisely removing the specified data.

Doctors' registration.



Login for already registered or after registration.

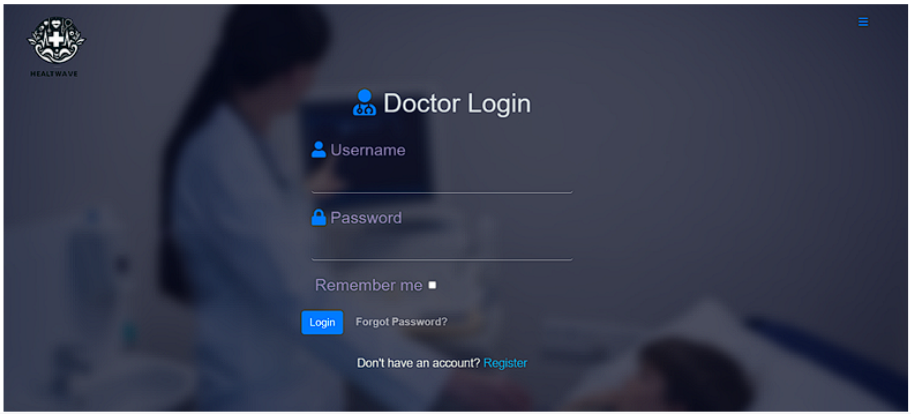


Fig. 3. HealthWave EHR System Register/Login Interface.

After successful login you move to dashboard with CRUD functionality on patient details.

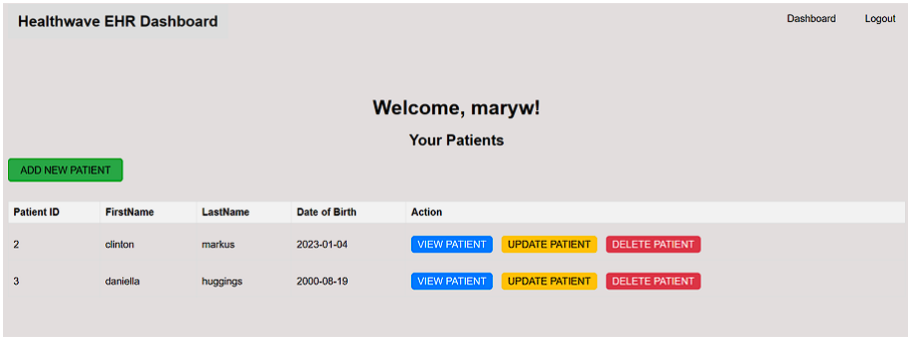


Fig. 4. HealthWave EHR System Dashboard Interface.

Fig. 5. HealthWave EHR System Patient Registration.

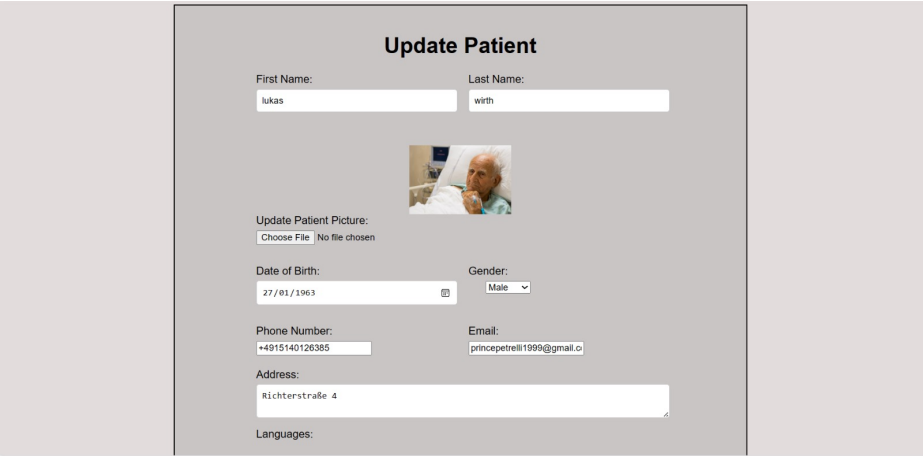


Fig. 6. HealthWave EHR System Patient Record Management.

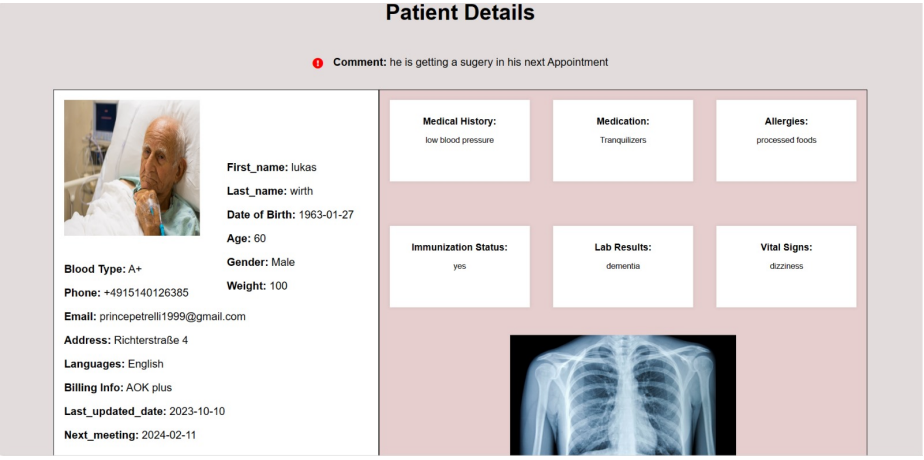


Fig. 7. HealthWave EHR System Patient Profile Access.

Our system enhances patient record management through secure CRUD operations - Create, Read, Update, and Delete. This ensures efficiency and high security in handling patient data, reflecting a comprehensive and holistic approach to data management.

4 Evaluation of the EHR Information System

In evaluating the Healthwave Electronic Health Record (EHR) System, our core focus was assessing various aspects integral to the healthcare professionals' user experience, significantly streamlining patient data management, enhancing the accuracy of records, and ultimately improving patient care quality.

The average scores provided insightful data. Integration with workflow scored highly at 4.30, as did support for complex cases (4.20) and learning speed (4.15), reflecting effectiveness in aligning with professional workflow and managing intricate healthcare scenarios. Overall usability and user confidence also scored strongly at 4.00 and 4.05 each, indicating a positive reception of the interface and functions.

However, the score for the likelihood of recommending the system to a colleague was relatively lower at 3.60. This suggests some reservations among users, which might stem from specific unaddressed needs or individual user experiences. It points to a potential area for further exploration and enhancement.

To provide a more comprehensive understanding of the system's usability, we calculated the average System Usability Scale (SUS) score for the HealthWave EHR system. The SUS score is calculated using the following mathematical formula:

For each of the ten SUS questions:

- For odd-numbered questions (1, 3, 5, 7, 9):

$$\text{Score}_{odd} = \text{User Response} - 1 \tag{1}$$

- For even-numbered questions (2, 4, 6, 8, 10):

$$\text{Score}_{even} = 5 - \text{User Response} \tag{2}$$

Then, the sum of these adjusted scores (ranging from 0 to 4 for each question) is calculated for each respondent. The overall SUS score is obtained by multiplying this sum by 2.5, converting the score range from 0-40 to 0-100:

$$\text{SUS Score} = \left(\sum_{i=1}^{10} \text{Adjusted Score}_i \right) \times 2.5 \tag{3}$$

Based on this calculation, the average SUS score for the HealthWave EHR system is 58.35 This score, while above the midpoint of the scale, indicates areas where the system can be improved to enhance user satisfaction and overall experience. The SUS score provides a quantitative measure to gauge the usability of the system and serves as a valuable tool for identifying specific aspects that may benefit from further refinement.

4.1 Questionnaire Snapshots

Figure 8 are the snapshots of the System Usability Scale (SUS) questionnaire that was employed to assess the usability of the HealthWave EHR system. Ten questions are presented, each designed to gauge the user's subjective experience with the system.

Users are asked to rate their agreement on a scale from 1 to 5, with 1 being a strong disagreement and 5 being a strong agreement. The questionnaire covers various aspects of the system's use, such as overall usability, integration into daily workflow, error management, and confidence in performing tasks. Additionally, it addresses the likelihood of recommending the system to a colleague, which indicates the system's perceived value among its users.

The results of this SUS questionnaire are integral to the continuous improvement of the HealthWave EHR system, providing actionable insights that can lead to enhancements in system design, functionality, and user support mechanisms. By regularly administering this survey and analyzing the results, the system can evolve to better meet the needs of its users, ultimately contributing to the overarching goal of improving patient care through efficient healthcare information management. The link to the form is: **https://shorturl.at/yRW18**

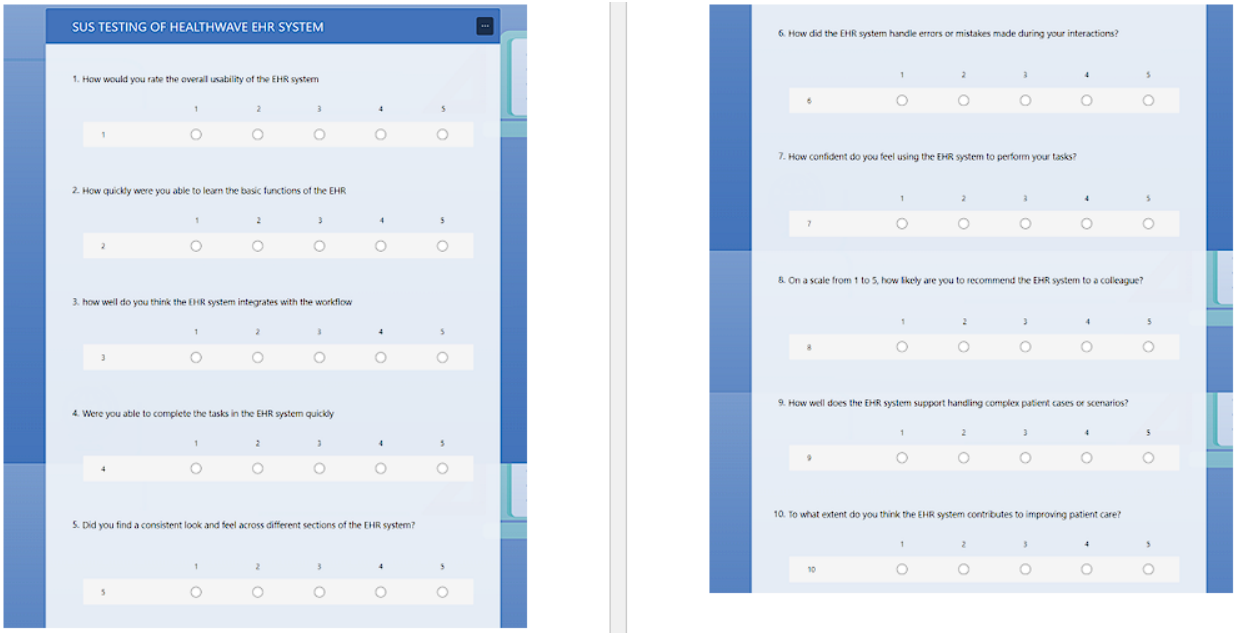


Fig. 8. SUS questionnaire snapshot.

5 Roles and Responsibilities

The successful operation of our project is the result of a collaborative effort, where each team member has distinct yet overlapping roles. Table 1 below outlines the specific responsibilities and tasks managed by each individual, highlighting the collaborative nature of our work.

Table 1. Team Members and Their Assigned Tasks

Ekanem Obo Effiong	Izuogu Princepaul Ebuka	Tabitha Wangaruro
- index.php / homepage - Logout.php - Dashboard.php/EHR doctor's interface - Edit/Update_patient.php - (CRUD) update patient form - Styles/ style.css - Help.php - Doctor's table (sql database) - Report/SUS test/ evaluations	- Register.php/ register form - Login.php/login form - Forgot password/phpMailer/ confirm.php - Create/Process_patients.php (CRUD) add new patient form. - EHR_style.css - Token.php - Patient's table (sql database) - Report/SUS test/ evaluations	- About us.php/ about us page - Db.php/ database linking - Export_patients.php/ save patient csv file - Get/View_patients.php (CRUD) view patient EHR - View.css - Uploads/.css Folders - Token table (sql database) - Report/SUS test/ evaluations

6 Conclusion

In conclusion, our project on the HealthWave Electronic Health Record (EHR) system provides a glimpse into the potential of digital solutions in healthcare. Throughout this project, we aimed to create an EHR system that is functional and user-friendly, catering to the needs of healthcare providers and patients alike. We achieved this through a carefully designed web interface, a secure and efficient backend, and features that enhance patient-provider communication.

Our evaluation, particularly using the System Usability Scale (SUS), highlighted the strengths of HealthWave, such as its integration with professional workflows and support for complex case management. However, it also pointed

out areas where improvements are needed, such as enhancing user satisfaction and system recommendation likelihood.

For future work, we propose the following:

1. Enhanced Security Measures: While HealthWave currently uses MD5 for password hashing, upgrading to more secure methods like bcrypt or SHA-256 can provide better protection against modern cybersecurity threats.
2. Mobile Application Development: Developing a mobile app version of HealthWave could significantly improve accessibility and convenience for users, allowing healthcare professionals to access patient records on the go.
3. Incorporating AI and Machine Learning: Integrating AI algorithms can help in predictive analytics, like identifying patient risk factors based on their medical history, which can be crucial for preventive healthcare.
4. Interoperability with Other Systems: Ensuring that HealthWave can seamlessly exchange data with other EHR systems and healthcare tools will improve its functionality and user experience.
5. User Feedback and Continuous Improvement: Regularly collecting feedback from users and making iterative improvements based on this feedback will ensure that HealthWave remains relevant and effective in meeting the evolving needs of the healthcare industry.
6. Training and Support: Developing comprehensive training materials and support systems for users can enhance the adoption rate and overall effectiveness of the HealthWave system.

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