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Web-Mobile Platform for OSAHS Patients' Management

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Abstract – This paper introduces a web-mobile platform designed to address the challenges of diagnosing and managing Obstructive Sleep Apnea Hypopnea Syndrome (OSAHS), affecting 5% of adults and 2% of children aged 4-5 years. The platform integrates Python for biosignal preprocessing, Visual Studio Code and JavaScript for frontend development, and Node.js on Amazon Web Services (AWS) for scalable backend operations. Over 80% of medical professionals found the platform's functionality satisfactory or excellent, highlighting its user-friendly interface and comprehensive data access for informed decision-making. Patients benefit from real-time access to medical data, contributing to improved satisfaction and engagement in their care. The platform underwent comprehensive testing to verify its intended functionality, ensuring reliability and usability across diverse healthcare settings. Ongoing enhancements focus on usability and expanding functionalities to meet evolving healthcare needs.

***Keywords*:** Obstructive Sleep Apnea Syndrome, Web-mobile platform, Biosignal preprocessing, Node.js, React.js, AWS.

1. Introduction

Obstructive Sleep Apnea Hypopnea Syndrome (OSAHS) is a common, chronic, and progressively evolving disorder. It is a prevalent disease, affecting 5% of the adult population and 2% of children aged 4 to 5 years. It has a medium—to long-term cardiovascular side effects that deteriorate the quality of life. The most important symptoms are snoring, repeated respiratory pauses, and occasional drops in oxygen saturation. It has effective and cost-efficient treatment, making its diagnosis and treatment mandatory [1]. Among the biosignals used for the diagnosis and medical research related to sleep apnea are pulse, electrocardiogram (ECG), blood oxygen saturation (SpO2), airflow (breathing), body temperature, thoracic movement, galvanic skin response (GSR - sweating), blood pressure (sphygmomanometry), and thoracic movement [2]. These biosignals provide critical information for diagnosing and monitoring OSAHS, but their effective integration and real-time analysis remain a significant challenge.

Despite the availability of effective treatments for OSAHS, the current methods for diagnosing and monitoring the condition often need to be more cohesive and efficient. Traditional systems for collecting and analyzing biosignals need to be adequately integrated, leading to delays in diagnosis, inconsistencies in data interpretation, and increased costs for healthcare providers and patients. Additionally, many existing systems need more user-friendly interfaces, which hampers their adoption by medical professionals and patients. Additionally, clinical analysis procedures are performed by technicians and interpreted by trained personnel, who are not necessarily present during the test. Therefore, a tool that integrates biomedical information and allows for interpretation and continuous monitoring from any geographical location becomes necessary.

On the other hand, the evolution of new technologies in the medical industry has enabled the development of new signal processing and visualization algorithms, as well as the creation of different telematic solutions (WebApps) that are fundamental in integrating medical information recording and visualization processes and a conglomerate of content and functionalities that facilitate medical diagnosis and disease detection [3-14].

In response to these challenges, this work presents the development of a web-mobile platform that includes the registration and visualization of signals and medical information of patients with sleep apnea disease. The platform aims to streamline the data collection and analysis process, providing a comprehensive and user-friendly tool for healthcare professionals. The web platform is tested and evaluated by a physician group, who verify the usefulness and functionality of each element and

function that the tool contains. The observations and recommendations that emerged after the evaluation contributed to improving and presenting a version adjusted to the needs of the users.

This paper presents the design of a web-mobile platform to visualize and record biomedical signals from patients with OSAHS. The manuscript begins with a description of the technological and management requirements of the platform, followed by a proposal that includes all the tools used in its development. It continues with the evaluation process, operability, and functionality of the entire system. Finally, it addresses the testing and verification of the proposed design, ensuring its functionality and utility in the remote monitoring and interpretation of clinical information of the patients

2. User Requirements for the Monitoring Platform

To ensure that the monitoring platform for patients with sleep apnea disease meets the practical needs of its users, the design team conducted extensive discussions with physicians and practitioners. These conversations provided valuable insights into the daily challenges healthcare professionals face in diagnosing and managing sleep apnea. The feedback from these medical experts directly informed the development of the platform features and functionalities, ensuring that it is tailored to real-world medical practices.

The platform must address several critical requirements to ensure effective and efficient use by medical professionals and patients. Firstly, it must feature a robust access interface for the web application, allowing users to navigate and interact with the system easily. A validation email process is necessary for user registration, ensuring only authorized patients can access their health data. Once registered, patients should be able to access their information without the capability to modify it, maintaining the integrity of the medical records, which is a responsibility reserved exclusively for physicians. This controlled access is crucial for maintaining data accuracy and meeting medical standards.

Additionally, the platform should facilitate a comprehensive patient registration process, including inputting personal data, a brief medical history, and relevant biomedical information. This data entry is essential for creating a complete profile for each patient, which can then be used for accurate monitoring and diagnosis. Visualizing biomedical signals, such as ECG and SpO2, must be available through a user-friendly Graphical User Interface (GUI) on the web platform. A reliable database is needed to securely store all medical and patient information to support these functionalities. Furthermore, the platform should allow for the visualization of the medical history of all patients, providing physicians with a holistic view of their patient's health status. Finally, the application should be designed as a single-page dynamic application, ensuring a seamless and responsive user experience.

These requirements highlight the need for a sophisticated and integrated system that not only facilitates accurate monitoring and diagnosis of sleep apnea but also enhances the overall user experience for both patients and healthcare providers. By addressing these needs, the platform aims to improve the management of sleep apnea, enabling timely interventions and better patient outcomes. The collaborative approach in defining these requirements ensures that the platform is a practical tool for enhancing patient care.

3. Description of the Proposed Solution

The design of the web-mobile platform for the registration, storage, visualization, and monitoring of patients with sleep apnea follows the scheme shown in Fig. 1. Several key tools and platforms were carefully selected to develop and implement the monitoring platform for patients with sleep apnea based on their specific capabilities and suitability for the project requirements.

The decision to use Python within the Spyder development environment for signal preprocessing and analysis was guided by the unique features of these tools. With its robust libraries and packages tailored for scientific computing and signal-processing tasks, Python was a natural choice. Its extensive support for data handling and analysis allowed efficient manipulation and preprocessing of biosignals extracted from renowned databases like Physionet and Capnobase [15], [16]. Spyder, with its integrated development environment (IDE) focused on scientific computing, provided a conducive environment for iterative development and debugging, essential for handling complex biosignal data effectively.

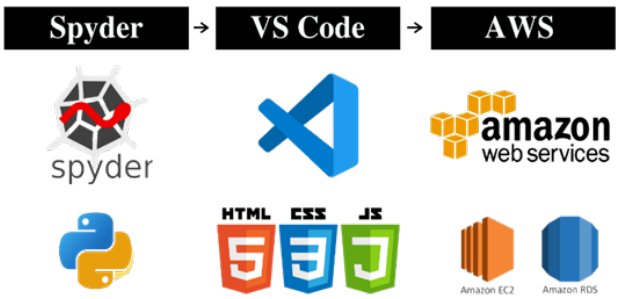


Fig. 1: General scheme of the developed tool.

Visual Studio Code was selected as the primary editor for its versatility and extensive ecosystem of extensions, which significantly enhanced productivity during the registration process. Its robust debugging capabilities and support for multiple programming languages facilitated seamless integration with Python for biosignal preprocessing and JavaScript for web development. This integration streamlined the development workflow, ensuring efficient coding practices and allowing for rapid iteration and debugging.

The platform needs for scalability, reliability, and a comprehensive suite of cloud services drove the decision to deploy it on Amazon Web Services (AWS). AWS, with its robust infrastructure, provided the necessary support to host and manage the platform server-side operations securely. Leveraging AWS capabilities ensured high availability and scalability, crucial for handling potentially large volumes of data generated by biosignal monitoring. AWS global infrastructure also supported efficient data storage and retrieval, improving the platform performance and reliability.

JavaScript was selected as the programming language for the web platform due to its widespread adoption, extensive ecosystem of frameworks and libraries, and compatibility with modern web standards. JavaScript versatility allowed for developing dynamic and interactive user interfaces crucial for visualizing biosignals and enhancing user experience. Its integration with Node.js for server-side development ensured a cohesive development environment, simplifying code reuse and maintaining consistency across the platform.

Node.js was chosen to develop the application server due to its non-blocking, event-driven architecture. It aligns well with handling concurrent requests and real-time data processing required in medical monitoring applications. Node.js lightweight and scalable nature supported seamless communication between the frontend and backend components of the platform, facilitating efficient data transmission and processing. This choice optimized performance and responsiveness, enhancing the platform ability to deliver timely updates and notifications to healthcare providers and patients.

MySQL was selected as the database management system for its proven reliability, robustness, and ease of integration with Node.js and JavaScript-based applications. As a relational database, MySQL offered structured data management capabilities suitable for efficiently storing and querying patient information and biosignals. Its ACID compliance ensured data integrity and consistency, which is crucial for maintaining accurate medical records and supporting regulatory compliance requirements.

A comparative evaluation of frameworks such as React.js, Vue.js, and Angular was conducted to select the most suitable frontend framework for the web platform. React.js was chosen for its component -based architecture, virtual DOM rendering, and strong community support. These features promoted modular development, enhanced performance, and facilitated the integration of complex data visualization components required for biosignal representation. React.js flexibility and scalability aligned well with the platform's evolving requirements, supporting continuous enhancement and adaptation to user feedback and technological advancements.

4. Platform Operation and Functionality

The platform features two primary user profiles: Medical and Patient, illustrated in Fig. 2. The Medical profile grants physicians access to the web platform to register patients and assign unique login credentials. These credentials undergo email verification using the SendGrid tool for secure authentication. Registration and login details are centrally stored in a cloud-based database, managing permissions. Conversely, upon login, patients can view their medical information. The

platform responsive design ensures seamless access across various mobile devices, emphasizing usability and accessibility as shown below.

Fig. 2: General diagram of the platform.

The web platform includes a user-friendly homepage showcasing different roles and functionalities. Medical users enjoy comprehensive access to all platform functionalities, including patient record modifications, making their work more efficient. In contrast, the Patient profile limits permissions to view personal medical histories, biosignals, and physician comments. Medical users initiate access through a straightforward registration, submitting their name, email, and password. SendGrid facilitates email verification and data validation via a server-side post-request mechanism.

After successful login, Medical users manage patient information effortlessly, with capabilities to add, view, edit, and delete records as needed. Patients are categorized using a traffic light system (Fig. 3), based on diagnostic severity or age-related risk factors, facilitating efficient monitoring and care prioritization.

Fig. 3: Patient registration page.

Visual and numerical biosignal analysis (Fig. 4) enables physicians to add diagnoses and access medication details, downloadable in PDF format for thorough review. This functionality not only enhances decision-making but also fosters collaborative care efforts among healthcare providers, making them feel supported and encouraged.

The platform responsive layout adapts dynamically to any mobile device screen size, enhancing user experience and minimizing usability challenges aligned with user-centric design principles (Fig. 5). This design approach ensures seamless access to critical information and functionalities, promoting effective healthcare management and patient engagement.

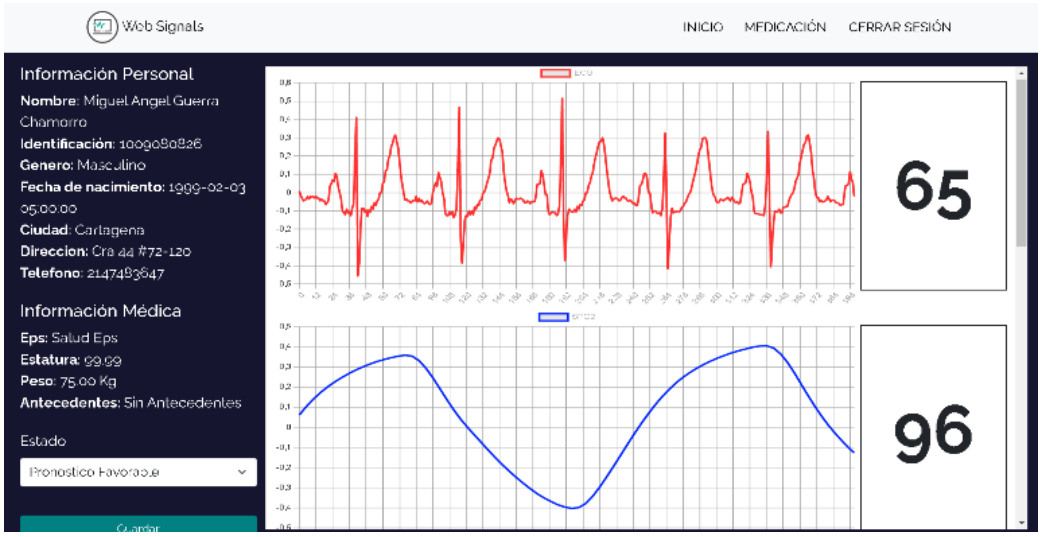
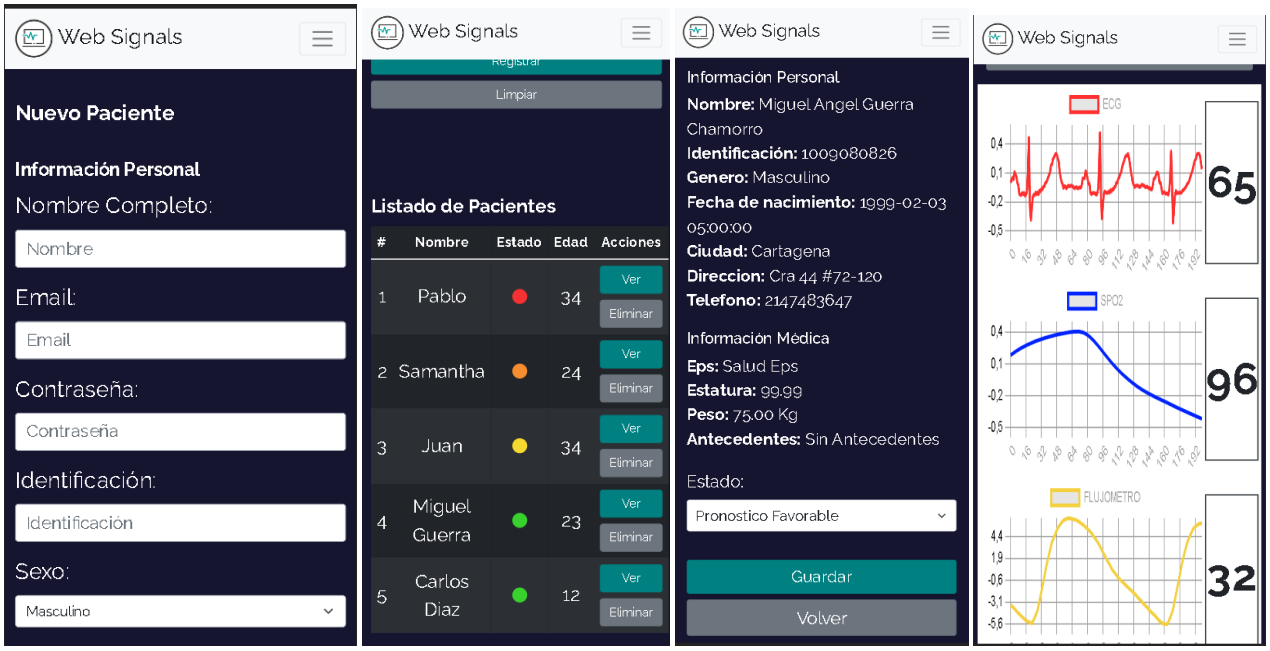


Fig. 4: Visualization page for patient biosignals.



(a) (b) (c) (d)

Fig. 5: Platform Responsive. (a) Personal Information, (b) Patient List, (c) Clinical History, (d) Patient Signals.

5. Platform Testing and Verification

Testing and verification procedures were conducted to ensure the platform reliability and functionality. The evaluation process involved automated and manual testing techniques to identify and address potential issues. The testing process was a collaborative effort between the development team and three medical professionals: a general practitioner, a cardiologist, and a pediatrician. This partnership ensured that the platform was tested in real-world scenarios and that the needs of the end-users were prioritized. Their feedback highlighted areas for improvement and confirmed the platform ease of use and effectiveness.

Functional testing was performed to verify that each platform feature operates as intended. Thus, testing included the registration and login processes, data validation using the SendGrid tool, and the hierarchical classification of patients. Each function was tested for different user roles to ensure the permissions and access controls worked correctly.

The database was tested to ensure the accuracy and integrity of stored data. This included verifying data insertion, update, deletion, and retrieval operations. The relational database (MySQL) was also tested for scalability to efficiently handle growing amounts of patient data.

Usability testing focused on the platform interface and overall user experience. Hence, a survey was designed to evaluate the feasibility of the developed tool involving a group of 15 physicians.

The primary goal of these tests was to examine the login components and patient registration process managed by the physicians, enabling necessary adjustments to be made. Tables 1, 2, and 3 outline the details of each test.

Table 1: Individual test.

Section	Test	Result
Doctor Registration	User not registered	Message for email validation
	Registered user	Message indicating that the user is already registered
	Incomplete fields	Message indicating that the fields are required
Login to the Web Application	User not validated	The server informs that the user needs to be verified
	Validated user	Successful access to the web platform
	Incorrect data	The server informs that the data does not match

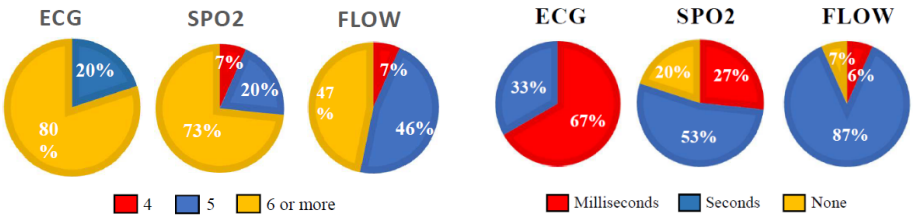
Table 2: Individual test – Medical role.

Section	Test	Result
Patient Registration	Incorrect fields	The field is only filled if the appropriate format is used
	Incomplete data	It is indicated that all fields are required
	Successful registration	Validation of creating the new patient by email and updating the list
Patient List	Correct hierarchy	List of patients with traffic light classification ordered by age: highest to lowest
	View/edit patient	Access to the panel with the data of the selected patient
Visualization Panel	View patient	The graphs and personal data of a patient are displayed
	Add comment	The doctor can add comments regarding the diagnosis, which will be stored in the database
Medical Formulation	Incomplete fields	It is indicated that all fields are required
	PDF generation	A PDF document is generated with all entered fields, which can be subsequently downloaded

Table 3: Individual test – Patient role.

Section	Test	Result
Patient Login	Unregistered patient	Message indicating the user is not registered
	Registered patient	Access only to the panel with personal data and biomedical signals, without modification permissions
	Incorrect data	The server informs that the data does not match

In the graphical presentation of the biosignals, it was essential to evaluate the number of visualization cycles, the amplitude, and the time units (seconds, milliseconds, or others). Over 70% of the evaluators agreed that at least six cycles should be visualized for ECG and SPO2 signals. For the flowmetry signal, most evaluators considered that representing five, six, or more cycles necessary to interpret the information (Fig. 6(a)) correctly. However, regarding the time scale, most evaluators agreed that the units should be given in milliseconds for ECG and in seconds for SPO2 and flowmetry signals (Fig. 6(b)).

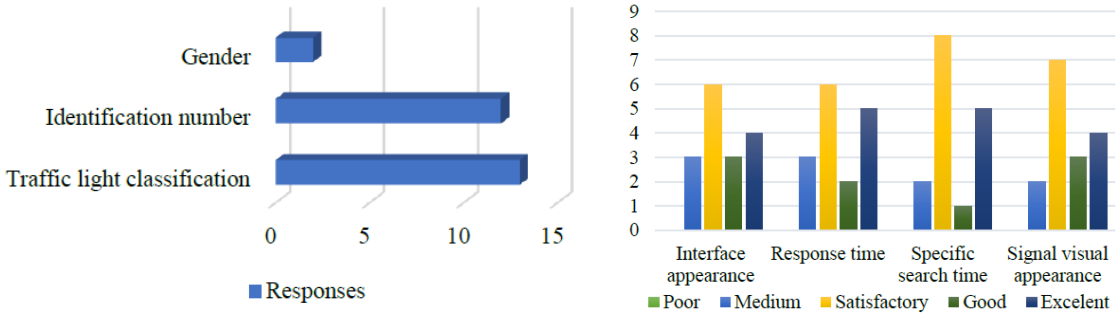


(a) (b)

Fig. 6: Survey response: (a) On number of cycles, (b) On visualization time scale.

The form included questions regarding the patient personal information for the patient preview section (list of registered patients). Specifically, it addressed whether additional information such as gender, identification number, and traffic light classification or alerts should be linked alongside the list number, name, age, and actions. It was found that 13% participants answered the Gender question, 80% of respondents considered a classification and alert generation feature important in the list, while over 70% suggested including an identification document option, as shown in Fig. 7(a).

Modifications were made accordingly, although the identification document option was not implemented due to space constraints within the screen layout. Regarding the use of the web platform, users responded to questions regarding functionality and content visualization. Responses were categorized as satisfactory or excellent for all users, with none selecting the option "poor", as shown in Fig. 7(b). Mobile visualization (on small devices) was deemed satisfactory. All survey participants responded affirmatively to the question, "Do you find mobile visualization (on a small device) pleasant, and is it possible to obtain information correctly?".



(a) (b)

Fig. 7: Response to the question: (a) Additional information (Gender, Identification Document, and Classification), (b). Functionality and content visualization.

Finally, an open-ended question was posed to gather user experience feedback and assess the system's viability based on comments. Results indicated that the platform meets expectations and is highly useful for monitoring patients with sleep apnea syndrome. Following the evaluation form results, necessary adaptations and adjustments were made, considering suggestions from experts. A traffic light classification, including age-based classification, was added for patient preview.

This addition helps to prioritize patients with a reserved prognosis and older patients. The recommendation to remove a patient from the list when no longer needed was also implemented. Regarding signal visualization, interactive graphs (pause and zoom functions) were incorporated for physicians, aiming to enhance user experience.

4. Conclusion

In conclusion, the development and implementation of the web platform have effectively addressed critical healthcare management needs, offering robust functionalities tailored for medical professionals and patients. The platform dual-profile system, comprising Medical and Patient roles, ensures secure and efficient handling of medical records and patient interactions. Medical users benefit from comprehensive capabilities to register patients, manage records, and conduct detailed biosignal analyses. For instance, over 80% of surveyed medical professionals found the platform functionality satisfactory

or excellent, particularly highlighting its ease of use and ability to enhance decision-making through interactive features and comprehensive data access. Patients, provided access to their medical histories and real-time information, are empowered to actively engage in their healthcare process, contributing to improved patient satisfaction.

Moreover, testing and validation processes have affirmed the platform reliability and usability. Collaborative efforts with medical professionals during testing yielded valuable feedback that shaped enhancements, ensuring the platform aligns with real-world healthcare practices. The platform responsive design has facilitated easy access from various devices, with mobile users expressing satisfaction in accessing critical health information conveniently. With a consistent positive response from users, including agreement on mobile usability among surveyed participants, the platform stands poised to support healthcare providers in delivering quality care effectively. As technological advancements continue to drive healthcare innovation, ongoing improvements will focus on enhancing user experience and expanding functionalities to meet the evolving needs of healthcare delivery.

As future work, creating a module in the platform where trained personnel can report the number of apnea events occurring in 1-hour intervals along with the duration of each event is proposed. This module would help establish a severity index that will contribute to more accurate diagnoses and decision-making.

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