Optimization of hospital surgical management through a digital system for traceability and scheduling of surgeries

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Abstract*– The traceability of surgical information is a key component of safe and efficient hospital management. In public hospitals in Honduras, surgical management faces limitations due to the use of manual processes for scheduling and registering surgeries. In response to this problem, which affects coordination between medical and administrative departments, increases wait times and limits the ability to respond to emergencies, a hospital surgery management system was optimized using Python and PostgreSQL. The system integrated functions for patient registration, operating room availability, surgical history, automatic reminders, and surgical statistics, providing a clear, real-time view of the surgical unit. Validation included interviews and surveys of healthcare staff, whose results highlight reduced errors, ease of use, and improved coordination of roles. Compared to manual methods, the system demonstrated greater efficiency and transparency, with an improvement of over 70% in operating times, establishing itself as an innovative and scalable tool for hospital management. The implementation of the system promotes efficient management, capable of digitizing key processes and improving surgical efficiency in resource-limited hospital settings.

Keywords*-- hospital systems, operating room management system, surgical management, surgical traceability.

I. Introduction

Management of hospital surgeries will be seen as an essential element in the operational efficiency of health systems, particularly in contexts where demand for the service exceeds installed capacity and there are significant technology constraints. In developing countries like Honduras, public hospitals will continue to face structural challenges related to reliance on manual processes, fragmentation of systems and information, and lack of traceability of surgical procedures. which directly affects the quality of service and patient safety [1], [2], [3].

Internationally, the literature will demonstrate that OR optimization will be widely addressed through process modeling, theory simulation and analysis approaches. Recent studies will show that the analysis of workflows will make it possible to identify weaknesses in coordination between medical and administrative staff, as well as inefficiencies in resource allocation [4], [5]. It will be evidenced that the lack of digital integration in the surgery blocks will lead to scheduling delays, information duplication and operational overload, affecting hospital productivity [5].

Similarly, the implementation of artificial intelligence and machine learning models will allow for optimized surgical block scheduling, reduced waiting times and avoidance of cancellations by applying predictive techniques [6]. However, these technological advances will be implemented mainly in contexts with advanced digital infrastructure which demonstrated a significant gap with their implementation in health systems with limited resources [7], [8].

In this context, the interoperability of health information systems will be a key element that ensures continuity of care and integration of clinical data. The use of standards such as HL7-FHIR will facilitate information exchange between different platforms, improving clinical coordination and decision making [9], [10]. However, several studies indicated that its implementation faced challenges related to technical incompatibilities, lack of alignment and limitations in technological infrastructure [11], [12], [13], [14]. These barriers will be especially critical in Latin America, where health systems will continue to operate in a fragmented manner [15], [16].

Moreover, the digitalization of hospital systems will involve new challenges in patient information security. Recent research has highlighted significant vulnerabilities in hospital systems against cyber-attacks, highlighting the need to implement robust authentication mechanisms, encryption and access control of users to manipulate [17], [18], [19]. Likewise, the use of emerging technologies such as digital signatures, blockchain, and artificial intelligence models will contribute to strengthening the integrity and confidentiality of clinical data, although it will also show limitations if not implemented under adequate security frameworks [20], [21], [22], [23], [24].

In the Latin American context, cybersecurity in health continued to face challenges associated with lack of investment, poor staff training and development of efficient public policies, which increased the vulnerability of clinical systems [25], [26], [27], [28]. Therefore, comprehensive strategies that combine elements of technology, organization, and continuous training will be needed to ensure the protection of the patients' health information.

At the same time, digital transformation will be established as a strategic axis to strengthen health systems, allowing for improved operational efficiency, quality of care provided and the data-driven decision-making [29], [30]. In Latin America, this process will propel the adoption of technologies such as artificial intelligence, data science and automation, although their implementation will be constrained

by structural, economic and organizational factors [31], [32], [33].

In Honduras, the problem will be evident in institutions such as the Regional Hospital Leonardo Martínez Valenzuela, where the surgical management will continue to depend on records and manual processes and tools like spreadsheets, creating delays in scheduling, duplication of information and limited ability to respond immediately to changes or emergencies. Despite preliminary digitization processes, these did not manage to comprehensively cover the optimization of surgical processes or ensure complete traceability of information [1].

In addition, the surgical delay will remain a critical problem in the Honduran health system, showing the need to implement technological solutions that allow for better planning, coordination and monitoring of procedures [3], [34]. In this sense, the digital transformation in the surgical area represents an opportunity to improve operational efficiency, reduce waiting times and reinforce patient safety.

Therefore, the present research will propose the optimization of a hospital surgical management system based on easily accessible technological tools, with the aim of improving the traceability of processes, optimizing surgical scheduling and improving coordination among health care staff. It will also seek to assess its impact on operational efficiency and its feasibility as an adaptable solution for hospital environments with scarce resources.

II. Methodology

The research adopts a mixed-methods approach, combining quantitative methods focused on the analysis of clinical and operational data extracted from the operating room, which will be used in simulations to objectively analyze the system's effectiveness. The qualitative method, meanwhile, is based on collecting opinions and evaluations through surveys of healthcare personnel involved in surgical processes, which allows for an assessment of their perceptions of and experience with the system. The combination of both methods provides insight into the technical and human performance of the proposed system.

The study is classified as explanatory in scope because it seeks to establish causal relationships between variables. This scope allows us to determine why and under what conditions a phenomenon occurs; consequently, it is posited that the incorporation of functional improvements into the system directly influences the system's efficiency, traceability, and safety. Furthermore, the research design is quasi-experimental, as it involves pre-established groups and the application of measurement instruments at different stages; although the environment is not fully controlled, certain technical elements can be manipulated to observe their impact on the dependent variable.

Given that the study involves system optimization, a public hospital in Honduras with a similar profile was selected—the same hospital where the system was originally designed by biomedical engineers Martínez and Paredes [1]. The choice of this sampling method is based on the need to have key informants with direct experience in the management and use of the surgical system. Although this sampling method does not allow for the generalization of results to the entire population, it does provide contextualized and valuable information that significantly aids in analyzing and validating the proposed system. The methodology was organized using a sequential, feedback-driven approach, in which each phase builds on the findings of the previous one, allowing for progressive improvements to the system.

A. Research variables

The dependent variable focuses on the optimization of the surgical management system, evaluating aspects such as information traceability, data security, coordination of roles, and operational efficiency. The independent variables, meanwhile, included external factors such as the availability of computer equipment, connection stability, the hospital's internal organization, and staff resistance to change, all of which directly influence the system's implementation. It is important to note that, although the first two independent variables are considered in the analysis, they are not variables that the research team can control, as they depend on the hospital's structural and budgetary conditions. Nevertheless, their influence will be observed and documented as part of the contextual analysis.

B. Techniques and Tools

Software tools such as pgAdmin (PostgreSQL) were used for database management and validation, and Visual Studio Code (Python) was used for the development of programming and optimization modules. Research techniques included a literature review of the current system, semi-structured interviews with management and medical staff to identify needs, and surveys administered to end users to measure their perceptions of the system's ease of use, error reduction, and efficiency. This combination provided a comprehensive view of the problem and validated the relevance of the proposed optimizations.

C. Data collection

A literature review of the current surgical management system was conducted, identifying limitations in manual surgery scheduling, duplicate records, and a lack of traceability. Operational data from the surgical unit was collected through semi-structured interviews with medical and administrative staff and management, including scheduling times, cancellations, and operating room availability, which served as input for the design of the optimized system.

D. System verification and validation

First, the simulation phase was carried out, using actual historical data from the hospital corresponding to December 2025 and January 2026. This data was organized into a

PostgreSQL database and used to replicate scenarios involving the scheduling, cancellation, and rescheduling of surgeries, as well as operating room availability. Additional simulated situations were created, such as the temporary unavailability of one or more operating rooms, to evaluate the system's response to operational changes. Consequently, the results obtained in these scenarios represent the system's performance under controlled test conditions and should not be interpreted as measurements derived from ongoing clinical operations.

Subsequently, the validation process included functional verification, a comparison of operational indicators, user surveys, and a technical evaluation conducted by specialists in health information systems. The user evaluation focused on the usability and perceived usefulness of the optimized modules, while the expert evaluation analyzed functionality, security, interoperability, and adaptability. These activities were carried out in a hospital setting using use cases derived from surgical processes; however, they constitute validation activities and not tests of long-term production operation.

Finally, the optimized system was not evaluated as a continuously operating production system for all of the hospital's surgical activity. Therefore, the study does not aim to demonstrate sustained real-world clinical operation or long-term effects on hospital performance. Instead, the results demonstrate the technical and operational feasibility of the proposed solution using real hospital data, controlled simulations, and validation.

The validation was supplemented by interviews with technical experts in medical informatics, satisfaction surveys of medical and administrative staff, and comparisons with existing systems such as GNU Health. This confirmed that the optimized system offers greater surgical traceability and flexibility in indicators, better adapting to local needs. This comparison showed that, although GNU Health is a robust hospital system, it has limitations in surgical management. Therefore, a strategic option would be to integrate both systems, leveraging GNU Health's general coverage and the specific functions of the proposed system for surgeries.

III. Results & Discussion

[1] *System optimization*

Modules were developed in Python and integrated with PostgreSQL as the database management system, designed to handle critical functions: patient registration, operating room availability, history of performed and canceled surgeries, rescheduling, generation of automatic reminders, and real-time statistical visualization (Table 1). The system architecture was designed to ensure scalability and sustainability in hospital settings with limited resources, incorporating additional libraries to improve the graphical interface and enable data export in accessible formats.

TABLE I
Optimizations Carried Out In The System

Module	Initial system	Optimized system
Surgical record	Basic data	Includes patient identity, address and phone number.
Viewing surgeries	Simple lists with cancel/validate option	Filters by identity, name, medical specialty and type of surgery; options to cancel, validate or edit.
Surgical calendar	Module not available	Daily schedule with scheduled surgeries.
Availability of operating rooms	Option to enable/disable operating room	Same option plus a schedule of operating rooms enabled/disabled per day
Surgery history Poor record	Surgery history Poor record	Surgery history Poor record
Cancellation history	Poor registration	Search filters and reschedule option
System security	No additional mechanisms	Digital signature for critical actions (cancel, validate, reschedule).
Automatic reminders	Module not available	Notifications two hours before each surgery, plus the option to cancel the surgery from that same window.

Since the system handles clinical and surgical information, security mechanisms were implemented at the application, database, and infrastructure levels. At the application level, access is differentiated based on user roles, including management, administrative, and medical staff. Each role has access to the functions necessary for its responsibilities, which reduces the possibility of unauthorized modifications to surgical information. Access to PostgreSQL is further restricted through user credentials and passwords.

For critical surgical operations (including validation, cancellation, rescheduling, and other sensitive actions), the system requires an additional digital signature mechanism before completing the operation. The system also maintains records of surgeries performed and canceled and allows the generated reports to be exported as password-protected PDF files, providing additional mechanisms to preserve and review surgical information.

To illustrate the improvements implemented in the system, representative screenshots of some of the optimized modules are presented below. These images show how the surgery log was expanded to enhance traceability, as shown in Fig. 1.

Fig. 2 also shows how the scheduled surgeries view module incorporates advanced filters and editing options.

Finally, Fig. 3 demonstrates how the daily surgical calendar enables clearer and more efficient planning.

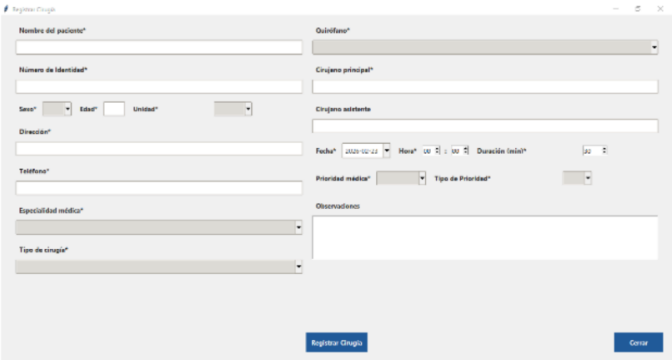


Fig. 1 Surgery registration module

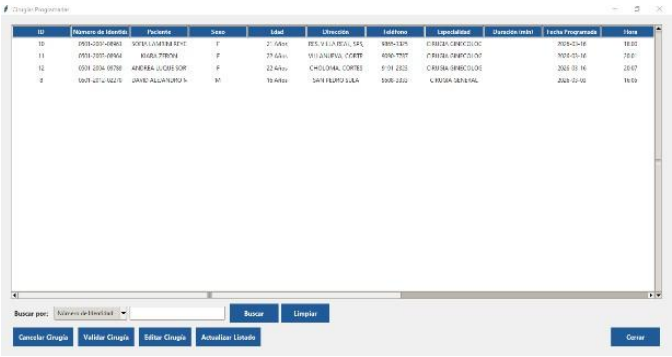


Fig. 2 Scheduled surgery module

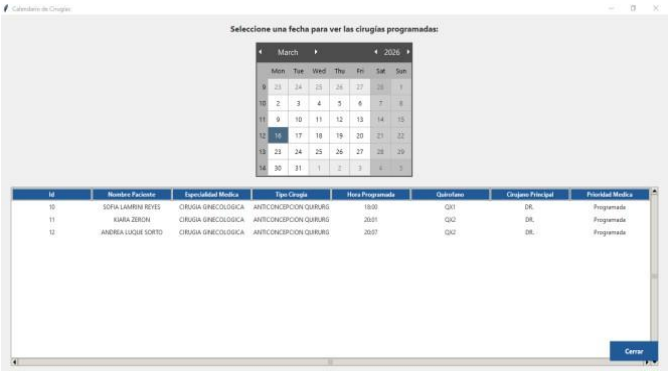


Fig. 3 Surgical calendar

[2] *Cost Analysis for Implementation*

The cost analysis shows that the optimized system can be implemented with a low investment, estimated at between $720 and $2,200, thanks to the use of existing infrastructure and the elimination of software licenses. To ensure system stability, proper planning is required that addresses aspects such as secure server location, a stable connection, power protection via a UPS, and regular preventive maintenance. It is also essential to establish information security policies, perform backups, and ensure phased implementation with pilot tests in the surgical unit before expanding to other departments. Finally, the human factor is key: staff training and the use of a user manual make adoption easier and ensure that the system's features are used correctly and efficiently. Taken together, these considerations ensure that the solution is viable, sustainable, and adaptable to the context of public hospitals with limited resources.

TABLE II
ESTIMATED COSTS FOR IMPLEMENTATION

Concept	Cost range
Optional Upgrades	$70 - $200
Infrastructure	$150 - $500
Software	$0
Labor	$500 - $1,500
Total estimated	$720 - $2,200

[3] *Staff Perception*

The surgical unit staff were evaluated through a satisfaction survey in which four members participated, with the aim of understanding their perceptions regarding the system's usability, functionality, efficiency, and usefulness. The survey consisted of 16 closed-ended questions regarding interface navigation, menu organization, surgery scheduling, cancellation and rescheduling, the surgical calendar, reminders, surgery history, response times, coordination among roles, and decision-making support. Additionally, a question on overall satisfaction was included at the end, using a scale from 1 to 5.

The results showed a favorable perception of various aspects of the system. Regarding navigation, 75% of participants indicated that the interface was easy or very easy to use, while 25% held a neutral view. Likewise, 75% considered the system's menus and options to be clear. Regarding surgery scheduling, 75% reported being satisfied with the ease of the process.

Among the most highly rated features were automatic reminders, which 100% of participants considered very useful, and the surgery history, which 100% considered very relevant. Similarly, 100% considered the system's loading time to be adequate and agreed that it facilitates coordination among the different roles in the operating room. Regarding decision-making support, 100% agreed or strongly agreed that real-time statistics and indicators are useful for this purpose.

Regarding efficiency, 100% of participants agreed that the system helps reduce administrative errors and improves the efficiency of surgical processes. Regarding the occurrence of glitches or delays while using the main functions, 50% reported experiencing none, while the other 50% reported experiencing only a few.

However, one area for improvement was identified in the process of canceling and rescheduling surgeries. Seventy-five percent of participants considered this process to be unclear, while 25% rated it as very clear. This result highlights the need to strengthen staff guidance and training on the use of this feature.

Finally, in the overall evaluation of the system on a scale of 1 to 5, 75% of participants gave a score of 4 and 25% gave a score of 3, resulting in an average score of 3.75 out of 5. Given the sample size, these results represent an initial

assessment by the participating users and help identify the system's strengths and opportunities for improvement, without attempting to generalize the results to the entire hospital staff (Fig. 4).

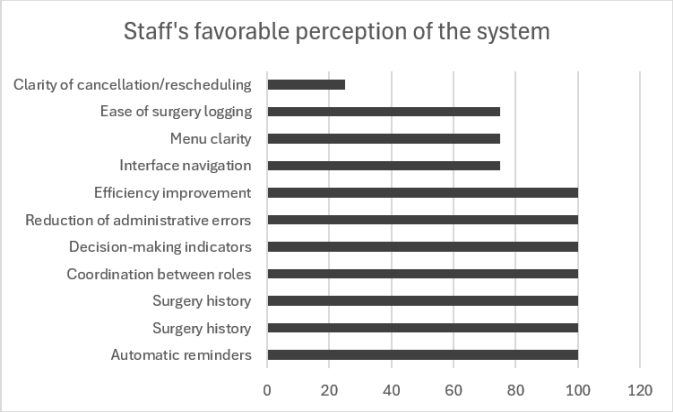


Fig. 4 Staff Perceptions of the System's Key Features

[4] *Time Comparison*

A comparison between the manual process currently used by the hospital and the optimized system has shown a marked reduction in surgical processing times. Under the traditional model, surgical scheduling relied on manual records, weekly planning meetings, and multiple spreadsheets managed solely in Excel, leading to data duplication and delays in decision-making by staff. In contrast, the system optimization has centralized information on a single platform, enabling direct entry into the system, immediate scheduling, and instant updates to procedures and their details.

TABLE III
COMPARISON OF TIMES: MANUAL VS SYSTEM

Process stage	Manual time (estimated)	System time
Initial patient registration	15 – 20 min	5 min
Surgical scheduling	1 week (pending meeting)	Immediate
Recording of completed surgery	30 – 40 min (data entry into Excel)	10 min
Cancellation and rescheduling	1 week (waiting for meeting)	Immediate

Significant reductions have been observed in processes such as patient registration, surgery scheduling, and rescheduling, as well as an immediate response to cancellations. When analyzing operational efficiency based on the data in Table 3, the transition from the manual model to the computerized system—specifically in stages such as surgery registration (from 35 to 10 minutes), results in a time savings of 25 minutes, or more than 70 percent, while also eliminating the wait times associated with weekly scheduling and rescheduling meetings.

$$\frac{25\ min}{35\ min} \times 100 = 71.4\% \quad (1)$$

[5] *Validation by experts*

The system has been evaluated by experts in systems engineering with experience in the healthcare field, who have confirmed that it meets criteria for functionality, security, and interoperability.

Various aspects have been positively evaluated, such as the clear interface, the organization of functions, and the implementation of security mechanisms such as digital signatures. Similarly, its ability to integrate with other hospital platforms through unique patient identifiers—such as the national ID number—has been confirmed, providing a benefit for the continuity of clinical information.

Thanks to its adaptability and scalability, the optimized system has been deemed a viable solution for implementation in real-world settings, such as resource-constrained public hospitals. Experts have generally validated the system as a timely solution for optimizing surgical management in a hospital setting.

[6] *Study limitations*

A major limitation of this study is that the evaluation should not be interpreted as a large-scale implementation of the system in a production environment. Although the study used actual hospital data from December 2025 and January 2026, part of the evaluation consisted of controlled simulations designed to replicate scenarios involving scheduling, cancellation, rescheduling, and operating room availability. In addition, user and expert evaluations were conducted as validation activities. Consequently, the reported improvements describe the performance observed during the evaluation and comparison procedures, rather than the long-term effects resulting from continuous, hospital-wide operation. Future work should evaluate the system over a longer period of actual operational use, with a larger number of users and a broader volume of surgical records.

IV. CONCLUSIONS

It has been possible to optimize the hospital surgical management system using easily accessible tools such as Python and PostgreSQL, showing an improvement in the operational efficiency of the Leonardo Martínez Valenzuela Hospital, with a decrease of more than 70% in administrative times and in the follow-up of surgical processes. The implementation of the system has proven to centralize information, accelerate the scheduling of surgeries and improve the facility's capacity to respond to cancellations and rescheduling by collaborating in reducing surgical delays and strengthening the functioning of the surgical area. It has been shown that the system is flexible and adaptable to different hospital and clinical management environments, even in contexts where no established standards have been established which require specific adjustments. but has reaffirmed its flexibility for implementation in public hospitals with limited resources.

Similarly, it has been verified that the integration of different functions within the same platform has improved the traceability of surgical procedures and at the same time tools such as calendars and automatic reminders have optimized the organization and coordination of the surgical block. Finally, the usefulness, acceptance and performance of the system has been validated by the establishment's health staff, and by a technical expert, highlighting its ease of use, speed and functionality, although the need to strengthen staff training in specific processes such as cancellation and rescheduling has also been identified, which will be important for maximizing their future implementation.

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