

Design and implementation of an integrated hospital information system in an anonymised private clinic: a UML approach and MVC architecture

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Abstract

The digital transformation of healthcare institutions is now a key challenge for improving the quality of care and hospital management. However, many healthcare organisations continue to face difficulties related to the manual management of records, the fragmentation of medical and administrative information, and delays in producing the statistics needed to manage operations.

This article presents the design and implementation of an integrated hospital information system for an anonymised private clinic. The approach adopted is based on the analysis of user requirements, the modelling of business processes using the UML language, and the development of a web application based on the Model–View–Controller (MVC) architecture.

The system developed incorporates the key functionalities required for the management of hospital activities, including user administration, patient management, appointment management, consultation management, admission management, laboratory test management and statistics. A centralised database has been set up to ensure the consistency, traceability and availability of information.

A functional validation phase based on several representative usage scenarios showed an estimated overall compliance rate of 92% with the requirements identified during the requirements analysis. Furthermore, a preliminary evaluation conducted among a sample of users revealed an overall satisfaction rate of 87%, particularly regarding ease of use, access to information and the speed of performing routine tasks.

The results obtained show that the proposed solution contributes to data centralisation, improved information flow and the structuring of hospital processes. This study confirms the value of integrated hospital information systems in the context of the digital transformation of healthcare institutions and opens up prospects for system interoperability, electronic patient records and the integration of decision-support features.

Keywords: hospital information system, digital transformation, UML, MVC architecture, web application, hospital management, private clinic, system

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I. Introduction

The digital transformation of healthcare institutions is now one of the key drivers for improving the quality of care and hospital performance. Hospital information systems (HIS) enable the collection, storage, processing and sharing of the medical and administrative information required for patient care and the management of healthcare facilities' operations. According to the World Health Organisation (WHO), health information systems play a vital role in the availability of reliable data, the monitoring of medical activities and support for decision-making within healthcare facilities [1].

Despite the progress made in the field of digital health, many institutions continue to face challenges related to the manual management of medical records, data fragmentation, information redundancy and poor integration between different hospital departments [2], [3]. These constraints limit the availability of information, increase the risk of errors and complicate the production of the indicators needed to manage medical and administrative activities.

In several African countries, the challenges are even more pronounced due to the organisational, financial and technological constraints faced by healthcare facilities. Bagayoko [4] highlights that the lack of integrated hospital information systems reduces the traceability of medical information and limits the effective use of health data. Similarly, Chougrani et al. [5] show that data quality, availability and use in decision-making processes are key determinants of hospital performance.

Furthermore, recent developments in hospital information systems now go beyond the simple administrative management of patients. Health data has become a strategic resource enabling the monitoring of

activities, performance evaluation, decision support and, more recently, the integration of artificial intelligence and predictive analytics techniques [6].

In this context, this study proposes the design and implementation of an integrated hospital information system for an anonymised private clinic. The aim is to develop a single platform enabling the centralised management of key hospital activities whilst improving the availability, consistency and traceability of medical and administrative information.

The approach adopted is based on the analysis of user requirements, the modelling of business processes using the UML language, and the development of a web application based on the Model–View–Controller (MVC) architecture. The system developed includes, in particular, the management of patients, appointments, consultations, hospital admissions, laboratory tests and hospital statistics.

The main contributions of this article are as follows:

- proposal of an integrated architecture tailored to the needs of a private clinic;
- modelling of hospital processes using UML;
- development of a web application based on the MVC architecture;
- centralisation of medical and administrative data;
- functional validation of the solution through several representative usage scenarios.

The remainder of the article is organised as follows. Section 2 presents related work on hospital information systems and the digital transformation of healthcare institutions. Section 3 describes the methodology adopted and the design of the proposed system. Section 4 presents the results obtained and a discussion of them. Finally, Section 5 concludes the study and outlines prospects for future work.

II. Related work

2.1. Hospital information systems

Hospital information systems (HIS) are now a central component of healthcare facility management. They enable the collection, storage, processing and sharing of the medical and administrative information required for patient care and the running of hospital facilities [1]. According to Lenay and Moisdon [2], HISs are no longer limited to the archiving of medical data but also play an important role in the organisation of hospital activities and decision support.

Several studies have shown that the computerisation of healthcare facilities helps to improve the availability of information, coordination between departments and the quality of patient care [3], [4]. Bagayoko [4] emphasises in particular that the integration of different hospital processes is a key factor in the success of digitalisation projects in African healthcare facilities.

2.2. Digital transformation of healthcare organisations

Recent digital initiatives prioritise interoperability to facilitate the secure sharing of health data [16, 17]. Digital transformation is essential for improving quality, planning and decision-making in healthcare systems [1]. Current programmes emphasise modernisation, data security, electronic health records and the importance of change management and user buy-in [9].

2.3. Process-based approach and modelling of hospital systems

Hospitals are characterised by the coexistence of numerous processes involving different stakeholders and resources. Augusto [8] considers that understanding and modelling hospital workflows is an essential step in improving the organisation of care and the performance of healthcare facilities.

In this context, the use of UML has become widely established as a modelling tool for representing functional requirements, interactions between stakeholders and the structure of complex information systems [7]. UML modelling also facilitates communication between users and system designers.

Furthermore, the process-based approach allows for a better representation of the interactions between different hospital activities such as admission, consultations, laboratory tests or hospitalisation [8].

2.4. Quality and security of health data

Data quality is a major challenge in hospital information systems. Incomplete, redundant or incorrectly entered data can compromise the reliability of hospital statistics and limit the ability of hospitals to manage their operations. Cadalbert et al. [11] demonstrate in particular that quality control and data validation mechanisms contribute to significantly improving the reliability of hospital data and its use for administrative and decision-making purposes.

Incomplete or inconsistent data can compromise the reliability of hospital statistics and limit the management capabilities of healthcare institutions [9].

The security of medical information is also a fundamental requirement. As health data is particularly sensitive, its processing requires the implementation of access control, authentication and traceability mechanisms to ensure its confidentiality and integrity [4], [5].

2.5. Health data and decision support

Recent developments in hospital information systems show that medical and administrative data have become a strategic resource for healthcare institutions. According to Dioszeghy [6], the use of hospital data helps to improve operational management, performance evaluation and decision-making.

This development also paves the way for the integration of advanced data analysis and artificial intelligence techniques designed to optimise the organisation of care and the allocation of hospital resources [10].

2.6. Critical review and positioning of the study

A review of the literature shows that existing research focuses primarily on the digital transformation of healthcare institutions, improving data quality, and the integration of hospital processes. However, few studies describe in detail the design and implementation of an integrated hospital information system applied to a private clinic in a context of limited resources.

This study addresses this gap by proposing an approach based on requirements analysis, UML modelling and MVC architecture to develop an integrated platform covering the main medical and administrative activities of an anonymised private clinic.

Table 1. Comparative Analysis of Related Work in Hospital Information Systems

Reference	Domain	Integrated HIS	UML	Validation	African Context	Private Clinic
Bagayoko (2010)	Hospital Information Systems	Yes	Yes	Yes	Yes	No
Chougrani et al. (2013)	HIS Evaluation	No	No	Yes	No	No
Augusto (2008)	Hospital Process Modeling	No	Yes	Yes	No	No
Elouadi (2011)	Hospital Process Management	Partial	Yes	Yes	No	No
WHO (2024)	Digital Transformation	Yes	No	Yes	International	No
Present Study	Private Clinic HIS	Yes	Yes	Yes	Yes	Yes

III. Methodology

3.1. Study Setting

This study was conducted in a private clinic, the identity of which has been deliberately withheld to protect the confidentiality of institutional information. The clinic provides a range of medical services, including consultations, hospital admissions, laboratory tests and administrative tasks associated with patient care.

Prior to the implementation of the proposed system, information management relied mainly on paper-based records and isolated office software tools. This situation led to difficulties in monitoring patients, retrieving records and producing administrative statistics.

Figure 1. Research Methodology Adopted in the Study

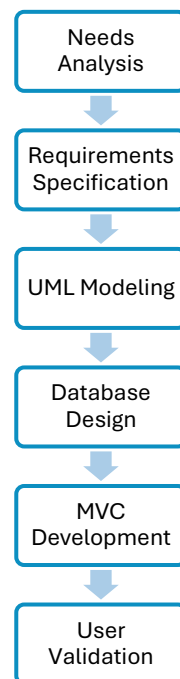


Figure 1. Research methodology adopted for the design and implementation of the proposed hospital information system.

3.2. Analysis of the existing system

A preliminary study was carried out to identify the shortcomings of the existing management system. This analysis revealed several constraints, notably:

- the fragmentation of medical and administrative information;
- the frequent use of paper documents;
- the duplication of certain data;
- difficulties in accessing patient records quickly;
- the lack of a centralised system for monitoring activities;
- the manual production of statistics.

These factors formed the basis for defining the functional requirements of the proposed new system.

3.3. Requirements gathering and analysis

According to Riccio [12], a significant proportion of the failures identified in information systems result from inadequate identification of requirements during the specification phase. Consequently, a thorough analysis of the expectations of the various stakeholders was carried out before proceeding to the design phase.

Requirements were identified through interviews, observation of procedures, analysis of administrative documents and examination of information flows. Using this method, the key stakeholders in the system were identified: administrator, receptionist, doctor, laboratory technician and manager. The requirements gathered were then converted into functional and non-functional requirements.

Table 2. Key functional requirements

Code	Functional Requirement	Priority
EF1	User Authentication and Access Control	High
EF2	Patient Record Management	High
EF3	Appointment Scheduling and Management	High
EF4	Consultation Management	High
EF5	Hospitalization Management	High
EF6	Laboratory Test Management	Medium
EF7	Statistical Reporting and Data Analysis	Medium

3.4. Process-based approach and UML modelling

The system design employs a process-based approach to describe the clinic's activities and interactions. Modelling using UML—through use-case, class, sequence and activity diagrams—formalised the functional requirements and defined the overall architecture prior to implementation.

3.5. Proposed system architecture

The modular organisation of the system also facilitates future adaptation and extension, in accordance with the software architecture principles described by Zouari [14].

The system uses a Model–View–Controller (MVC) architecture that separates presentation, business logic and data access. This approach follows the recommendations of Depaulis et al. [13], highlighting the advantages of multi-tier architectures for reducing coupling and facilitating the evolution of complex applications.

The system centralises all information relating to:

- patients;
- consultations;
- appointments;
- hospitalisations;
- laboratory tests;
- administrative statistics.

3.6. Database design

The relational database was built from the conceptual model created during the modelling phase. Key entities include:

- User
- Patient
- Appointment
- Consultation
- Hospitalisation
- Test
- Result
- Statistic

Entity relationships maintain data integrity and consistency.

3.7. Technologies used

The development of the system required the use of several development tools.

Table 3. Technologies Used in the Development of the Proposed System

Component	Technology / Tool
System Modeling	UML
Application Development	PHP
User Interface Design	HTML, CSS, JavaScript
Database Management System (DBMS)	MySQL
Web Server	Apache
Development Environment	XAMPP

These technologies were selected on the basis of their robustness, availability and widespread adoption in web application development.

3.8. System validation

A functional validation phase was carried out to verify that the system met the stated requirements.

Twenty-five test scenarios covering the main functionalities were executed. The results indicate that approximately 92% of the tested functionalities met the specified requirements correctly.

Furthermore, a preliminary evaluation conducted among fifteen users representative of the clinic's various profiles yielded an estimated overall satisfaction rate of 87%, primarily relating to ease of use, speed of access to information and the relevance of the features offered.

These results show that the system generally meets the expectations expressed during the requirements analysis phase.

IV. Results and Discussion

4.1. Overview of the developed system

The hospital information system developed enables the integration of the clinic's main medical and administrative activities within a single platform. The main objective is to centralise information relating to patients, consultations, appointments, hospital admissions and laboratory tests, whilst making it easier for different users to access and utilise this information.

Figure 2 shows the Global Use Case Diagram.

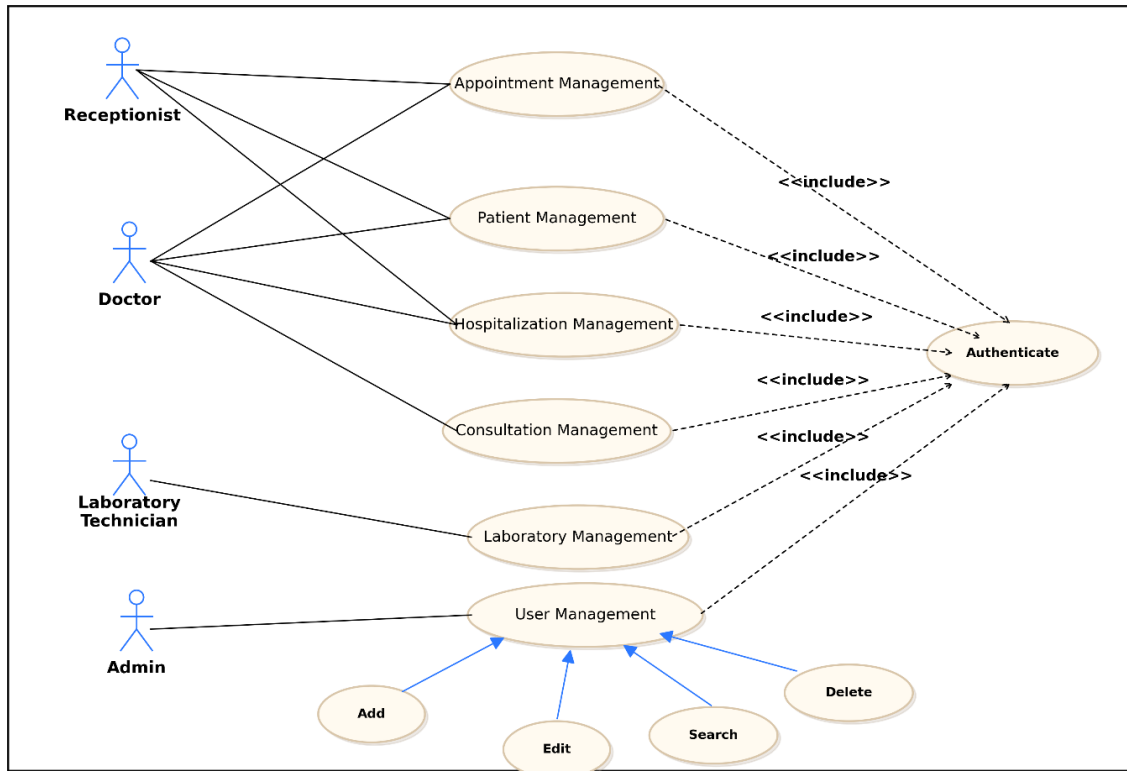


Figure 2. Global Use Case Diagram

The integration of the various modules helps to reduce data fragmentation and improve the consistency of medical information, in line with the recommendations set out in several studies on hospital information systems [1], [4].

4.2. System modelling

The modelling phase enabled the formalisation of interactions between the various stakeholders, as well as the main entities handled by the system.

Figure 3 presents a simplified UML class diagram highlighting the main entities and relationships of the proposed clinic management system. For readability purposes, only the core classes involved in patient management, consultations, prescriptions, hospitalizations, and user administration are represented. Secondary classes and implementation-specific details were omitted to improve the clarity of the architectural view while preserving the essential structure of the system.

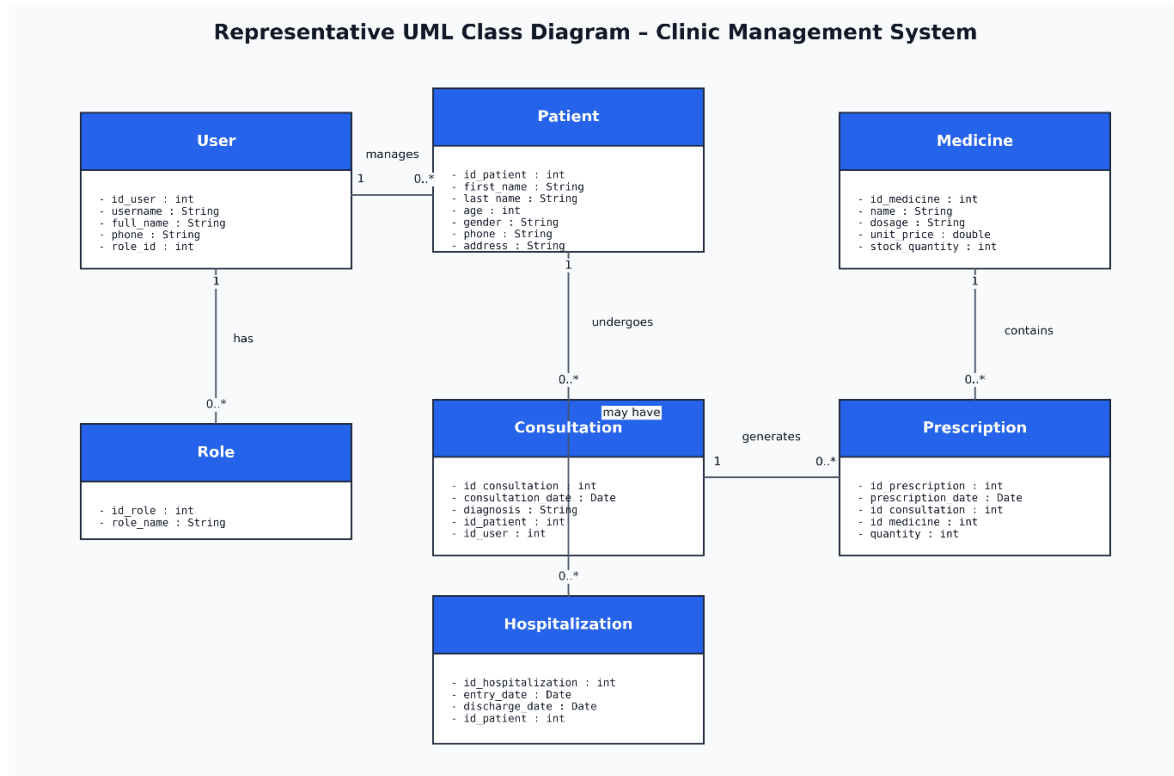


Figure 3. Simplified UML Class Diagram Highlighting the Main Entities and Relationships of the Clinic Management System

The resulting model highlights the relationships between the entities Patient, Consultation, Appointment, Hospitalisation, Examination and User. This structure facilitates the organisation of data and ensures its consistency within the database.

4.3. Software architecture

The application was developed using an MVC architecture, which separates the user interfaces, business logic and data access.

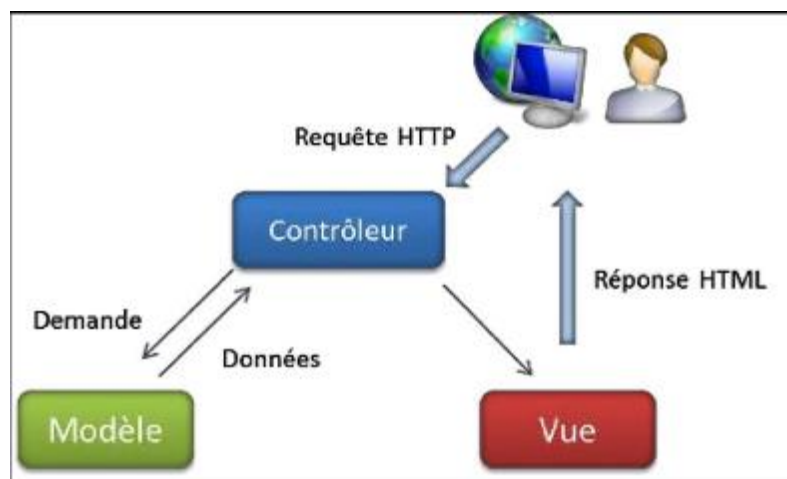


Figure 4. MVC architecture of the system

This architecture promotes the maintainability, scalability and reusability of the system, as recommended in the literature on the design of complex information systems [7].

4.4. Key features

Authentication and access management

The system implements an authentication mechanism that controls access to different features based on the user's profile.

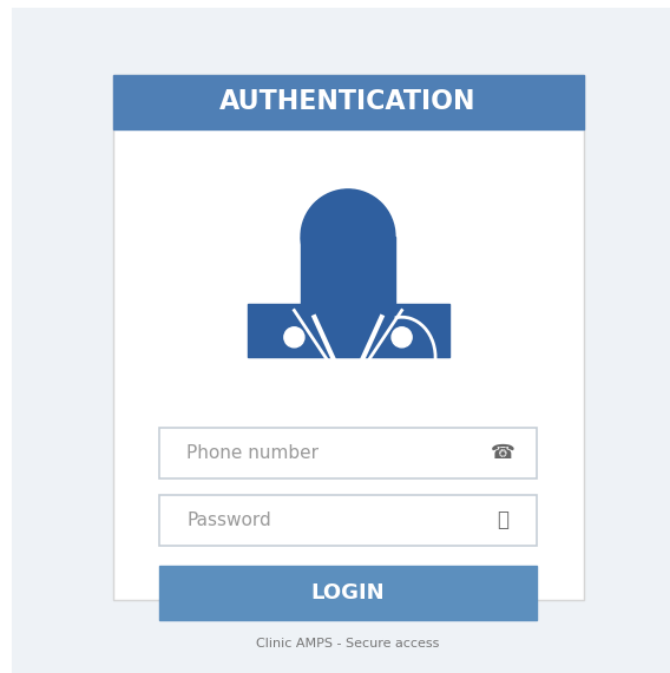
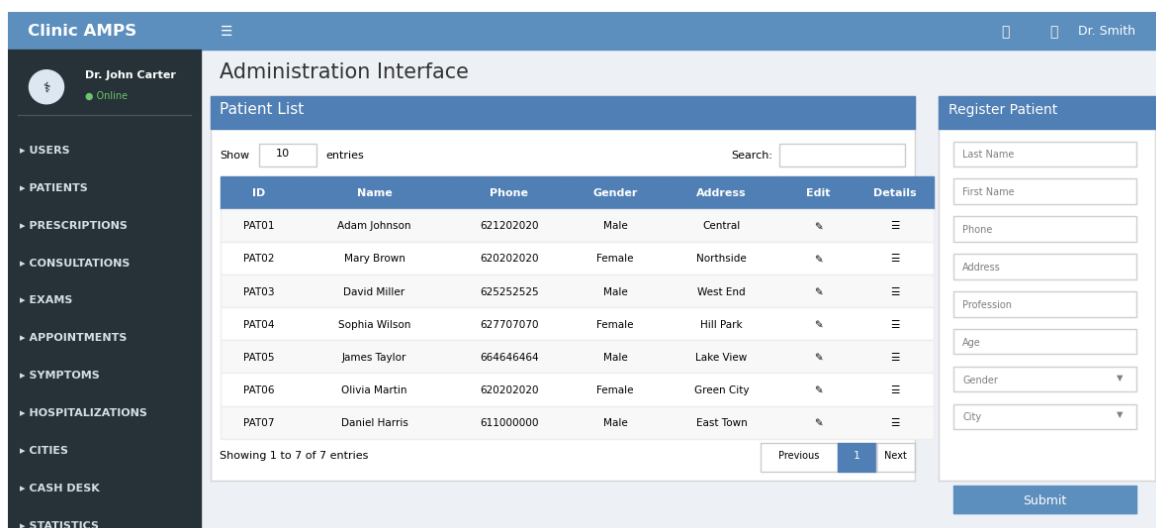


Figure 5. Authentication interface

This feature helps to enhance the confidentiality and security of medical data in line with the requirements of modern hospital information systems [5].

Patient management

The patient management module enables the creation, modification, viewing and searching of patient records.



ID	Name	Phone	Gender	Address	Edit	Details
PAT01	Adam Johnson	621202020	Male	Central	%	≡
PAT02	Mary Brown	620202020	Female	Northside	%	≡
PAT03	David Miller	625252525	Male	West End	%	≡
PAT04	Sophia Wilson	627707070	Female	Hill Park	%	≡
PAT05	James Taylor	664646464	Male	Lake View	%	≡
PAT06	Olivia Martin	620202020	Female	Green City	%	≡
PAT07	Daniel Harris	611000000	Male	East Town	%	≡

Figure 6. Patient management interface

Centralising information makes it easier to track the patient journey and reduces the risk of data loss or duplication.

Dashboard and statistics

The system includes a dashboard that displays key performance indicators relating to the clinic's activities.

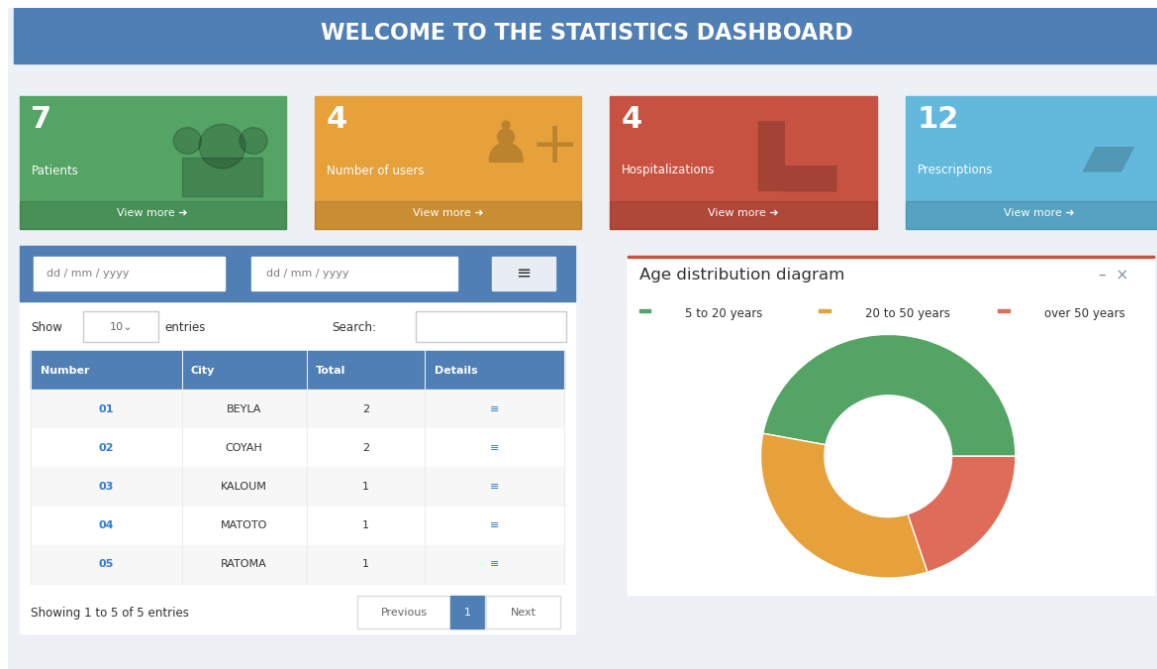


Figure 7. Statistical dashboard

The availability of these indicators facilitates the monitoring of activities and supports decision-making, in line with Dioszeghy's [6] conclusions regarding the utilisation of health data.

4.5. Functional validation

The system was validated using twenty-five test scenarios covering the main functionalities developed. To assess the compliance of the developed system with the identified requirements, a series of functional tests was conducted on the main modules of the application. Table 4 summarizes the results obtained during the validation phase.

Table 4. Results of Functional Validation

Functional Module	Test Cases	Passed Tests	Success Rate (%)
User Authentication	4	4	100
Patient Management	5	5	100
Appointment Management	4	4	100
Consultation Management	4	3	75
Hospitalization Management	4	4	100
Laboratory Management	4	3	75
Overall	25	23	92

The results presented in Table 4 indicate an overall success rate of 92%, demonstrating that most of the implemented functionalities operate according to the specified requirements. Full compliance was achieved for the authentication, patient management, appointment management, and hospitalization modules, while minor issues were identified in the consultation and laboratory modules, which can be addressed in future system updates.

Table 5. User Satisfaction Assessment

Evaluation Criterion	Satisfaction Rate (%)
Ease of Use	85
Information Accessibility	89
User Interface Ergonomics	84
Relevance of System Functionalities	90
Overall Satisfaction	87

Users have also reported a significant improvement in access to information and the organisation of administrative tasks. The table below presents an estimate of the system's perceived impact on several of the

clinic's operational indicators. The results suggest a reduction in the time required for certain administrative tasks, as well as improved availability of medical and administrative information.

A preliminary user evaluation was conducted to assess the usability and perceived usefulness of the proposed system. Participants were asked to rate several aspects of the application, including usability, information accessibility, ergonomics, and functionality relevance. The results are presented in Table 5.

Table 6. Perceived impact of the system.

Indicator	Before	After
Average time required to retrieve a patient record	8 min	2 min
Time required to generate a monthly report	3 h	30 min
Information availability	Moderate	High

The values reported in Table 6 were obtained from observations and feedback collected from administrative staff during routine activities. They should therefore be interpreted as operational estimates intended to illustrate the perceived impact of the system rather than as results derived from a controlled experimental evaluation.

As shown in Table 5, the proposed system achieved an overall satisfaction score of 87%, indicating a positive perception among users. The highest score was obtained for the relevance of the implemented functionalities (90%), suggesting that the system effectively addresses the operational needs of the clinic. Furthermore, the scores related to information accessibility (89%) and ease of use (85%) demonstrate the effectiveness of the user interface and the centralized management of medical and administrative data.

4.6. Discussion

4.6.1. Comparison with existing work

The results obtained show that the system developed meets the main needs identified within the clinic under study. The integration of modules for managing patients, consultations, appointments, hospital admissions and laboratory tests enables medical and administrative data to be centralised within a single platform. This approach is in line with the work of Bagayoko [4], which highlights the importance of integrated hospital information systems for improving the availability of information and the coordination of activities within healthcare facilities.

Furthermore, the centralisation of data observed in our study is consistent with the findings of Chougrani et al. [5], according to whom the quality, availability and effective use of data are key determinants of hospital performance. The implementation of a single database helps to reduce the risk of data duplication and facilitates the production of the indicators required for managing activities.

The statistical functions integrated into the system are also in line with the work of Dioszeghy [6], who regard health data as a strategic resource for improving hospital management and decision-making. Thanks to the availability of real-time information, clinic managers have a clearer overview of the activities carried out and the resources deployed.

The improvements observed in access to patient records and the production of administrative reports confirm the benefits generally associated with integrated hospital information systems [4], [5]. The time savings reported by users reflect improved information flow and a reduction in repetitive manual tasks.

Although the proposed system achieved a high overall validation rate, some functionalities, particularly those related to consultation and laboratory management, obtained slightly lower success rates than the other modules. These activities involve multiple actors and more complex workflows, which may increase the likelihood of operational inconsistencies during testing. This observation highlights the importance of continuous system refinement and user feedback in the deployment of hospital information systems.

Finally, the results obtained confirm the observations of Boudard and Mestres [9] regarding the importance of digital transformation in healthcare settings. The overall acceptance of the system by users suggests that the integration of digital tools can help improve organisational practices, provided that users' needs are properly taken into account from the design stages onwards.

While the overall satisfaction rate reached 87%, the results also indicate that certain aspects of the system can still be improved. In particular, usability and interface ergonomics obtained slightly lower scores than functionality relevance. These findings suggest that future developments should focus not only on expanding functionalities but also on enhancing user experience and interface design to increase user acceptance and satisfaction.

4.6.2. Contributions of the proposed system

The main contribution of this study lies in the proposal of an integrated hospital information system tailored to the needs of a private clinic operating within a context of limited resources. Unlike many complex

hospital solutions requiring significant infrastructure, the solution developed is based on widely available and easily deployable open-source technologies.

The combined use of requirements analysis, UML modelling and MVC architecture has enabled the implementation of a modular and scalable solution. This architecture facilitates system maintenance and offers the possibility of integrating new modules at a later stage without compromising existing functionalities.

The study also makes a significant organisational contribution by proposing the formalisation of hospital processes through UML diagrams. This approach promotes a better understanding of information flows and improves communication between the various stakeholders involved in the clinic's management.

Finally, the functional validation carried out shows that the system generally meets the requirements defined during the requirements analysis. The compliance rate achieved, as well as the level of user satisfaction, demonstrate the relevance of the proposed solution for the day-to-day management of hospital activities.

4.6.3. Limitations of the study

Despite the encouraging results obtained, certain limitations must be highlighted. Firstly, the study was conducted in a single clinic, which limits the generalisability of the results to all healthcare facilities. Needs and constraints may vary depending on the size, specialisation or level of equipment of the facilities concerned.

Secondly, the evaluation of the system is based primarily on functional tests and a preliminary survey of a limited number of users. A larger-scale trial would provide a more comprehensive assessment of the system's usability, performance and organisational impact.

In addition, the study did not include a longitudinal assessment of the system after deployment. Consequently, the long-term effects on clinical performance, staff productivity, data quality and patient satisfaction could not be evaluated within the scope of this research.

Thirdly, the study has not yet quantitatively measured certain performance indicators such as the reduction in time spent searching for records, improvements in staff productivity or the reduction in errors associated with manual information management. These elements represent important avenues for future research. Finally, certain advanced features, notably interoperability with other healthcare systems, the integration of a comprehensive electronic patient record, or the use of artificial intelligence techniques for decision support, have not yet been implemented and will be the subject of future developments.

V. Conclusion and outlook

This study focused on the design and implementation of an integrated hospital information system for an anonymised private clinic. Faced with the difficulties associated with the manual management of medical and administrative information, a solution based on requirements analysis, UML modelling and MVC architecture was developed to centralise data and structure the main hospital processes.

The system developed incorporates several modules covering the clinic's core activities, including the management of patients, appointments, consultations, admissions, laboratory tests and administrative statistics. The architecture implemented promotes the consistency, availability and traceability of information whilst facilitating access for the various authorised users.

The results of the functional validation show that the developed solution generally meets the requirements identified during the requirements analysis phase. The preliminary evaluation carried out with users also highlights good acceptance of the system as well as a perceived improvement in the organisation of the clinic's information and activities.

These results confirm the value of integrated hospital information systems as a driver of digital transformation in healthcare institutions. They are consistent with the conclusions of several recent studies highlighting the importance of data centralisation, the integration of hospital processes, and the availability of reliable information for management and decision-making.

Beyond the implementation of a software solution, this study demonstrates the relevance of combining requirements analysis, UML modelling and MVC architecture to support the digital transformation of healthcare institutions operating in resource-constrained environments. The findings suggest that a structured and user-centred design approach can contribute significantly to improving information management and operational efficiency within healthcare facilities.

Prospects

The integration of artificial intelligence techniques for predictive analytics and clinical decision support is consistent with the trends identified by Davenport and Kalakota [15].

Future work will focus on:

- the integration of a comprehensive electronic patient record;
- the development of advanced security and traceability mechanisms;
- improving interoperability with other healthcare systems;

- the implementation of more advanced decision-making dashboards;
 - the integration of artificial intelligence techniques for predictive analysis and medical decision support;
 - the evaluation of the system on a larger scale across several healthcare facilities.
- These developments will further strengthen the system's contribution to improving the quality of care and modernising hospital management.

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