

DocHub: A Technological Framework for Real-Time Access to Healthcare Services

Jugal Dambhare¹, Arpit Vitonde², Prof. Usha Kosarkar³

^{1,2,3}Department of Science and Technology,

^{1,2}G H Raisoni Institute of Engineering and Technology, Nagpur, Maharashtra, India

³G H Raisoni College of Engineering and Management, Nagpur, Maharashtra, India

ABSTRACT

Hospital Management System is an organized computerized system designed and programmed to deal with day-to-day operations and management of hospital activities. The program can look after inpatients, outpatients, records, database treatments, status illness, billings in the pharmacy, and labs. It also maintains hospital information such as ward id, doctors in charge, and department administering. The major problem for the patient nowadays is to get the report after consultation, many hospitals managing reports in their system but it's not available to the patient when he/she is outside. In this project, we are going to provide the extra facility to store the report in the database and make it available from anywhere in the world.

KEYWORDS: *healthcare, quality, efficiency, automation*

I. INTRODUCTION

A hospital management system (HMS) is a software solution that helps healthcare organizations and hospitals manage and streamline their various administrative, financial, and operational tasks. It is designed to centralize and automate processes, allowing healthcare providers to efficiently manage patient information, appointments, medical records, billing, inventory, and more.

The main reasons why hospitals use management systems are:

Efficient Workflow: HMS automates routine administrative tasks such as appointment scheduling, patient registration, and record-keeping. By reducing manual paperwork and streamlining processes, it improves overall workflow efficiency and enables healthcare professionals to focus more on patient care.

Information Management: HMS stores and manages patient records, including medical history, treatment plans, prescriptions, and test results. It provides a centralized and secure repository for healthcare data, making it easily accessible to authorized personnel. This helps in quick decision-making, accurate diagnosis, and personalized patient care.

Appointment Scheduling: HMS allows hospitals to efficiently manage appointments, including online booking, rescheduling, and reminders. It helps reduce waiting times, optimize resource allocation, and improve the patient experience.

Billing and Financial Management: Hospital management systems streamline billing processes, including insurance claims, invoicing, and payment tracking. It ensures accurate

and timely billing, reduces errors, and improves revenue cycle management. Financial reports generated by the system aid in budgeting, cost analysis, and financial decision-making.

Inventory Management: Many HMS include inventory management modules that track and manage medical supplies, equipment, and pharmaceuticals. This helps in maintaining optimum stock levels, preventing shortages, and reducing wastage. Effective inventory management ensures that necessary items are available when needed, thereby supporting efficient healthcare delivery.

Decision Support and Analytics: Hospital management systems provide data analysis and reporting capabilities, enabling hospitals to extract valuable insights from their data. This helps in identifying trends, monitoring key performance indicators, and making informed decisions for process optimization, resource allocation, and quality improvement.

Compliance and Security: HMS ensures compliance with healthcare regulations and data security standards. It helps in maintaining patient privacy, implementing access controls, and auditing system activities to prevent unauthorized access and data breaches.

In summary, a hospital management system is a comprehensive software solution that assists hospitals in managing their administrative, financial, and operational tasks. It improves efficiency, enhances patient care, facilitates accurate billing, optimizes inventory management, enables data-driven decision-making, and ensures compliance with regulations and security standards.

II. PRESENT SYSTEM IN USE

Database Management System: A robust database management system is essential for storing and managing patient information, medical records, inventory data, billing details, and other relevant data. Popular database systems include MySQL, Oracle, and Microsoft SQL Server.

User Interface: A user-friendly interface allows healthcare professionals to interact with the system easily. It should provide intuitive navigation, clear displays of information, and easy access to functionalities. User interface frameworks like AngularJS, React, or Bootstrap can be employed for developing responsive and user-friendly interfaces.

Patient Management Module: This module handles patient registration, demographic details, medical history, and appointment scheduling. It enables healthcare providers to efficiently manage patient information and track their interactions with the hospital.

Appointment Scheduling System: A scheduling system helps in managing appointments, facilitating online booking, rescheduling, and sending automated reminders to patients. It ensures optimal resource allocation and reduces waiting times.

Electronic Medical Records (EMR): EMR systems capture and store comprehensive patient medical records, including diagnoses, treatments, prescriptions, and lab results. It enables healthcare professionals to access and update patient records electronically, enhancing care coordination and continuity.

Billing and Invoicing: The billing module handles invoicing, insurance claims processing, payment tracking, and financial reporting. Integration with billing systems and payment gateways allows for seamless financial management and revenue cycle optimization.

Inventory Management: Inventory management modules track and manage medical supplies, equipment, and pharmaceuticals. It helps in maintaining optimum stock levels, reducing wastage, and ensuring timely procurement. Barcode scanning and RFID technology can be used for efficient inventory tracking.

Reporting and Analytics: This component generates various reports and analytics to provide insights into hospital operations, patient demographics, financial performance, and more. Data visualization tools such as Tableau or Power BI can be integrated to create visually appealing and interactive reports.

Security and Privacy Measures: Hospital management systems must ensure the security and privacy of patient data. This includes user authentication, access controls, data encryption, audit trails, and compliance with privacy regulations like HIPAA.

Integration with External Systems: Integration with external systems like laboratory information systems, pharmacy systems, and radiology systems allows for seamless exchange of data and information sharing between different departments.

III. NEED FOR THE NEW SYSTEM

Project Team: A dedicated project team consisting of skilled professionals is essential. This may include project managers, system analysts, software developers, database administrators, UI/UX designers, testers, and implementation specialists. The team should have expertise in healthcare IT and project management.

Requirements Gathering: Close collaboration with stakeholders, including healthcare providers, administrators, and end-users, is crucial to gather and document the specific requirements of the hospital management system. This includes understanding existing workflows, pain points, and desired features.

Budget and Funding: Adequate financial resources are necessary to cover the costs associated with the project. This includes software development, hardware infrastructure, licensing fees, training, and ongoing support. A budget should be prepared based on the project scope and requirements.

Infrastructure and Technology: A reliable and secure infrastructure is required to support the hospital management system. This includes servers, networking

equipment, backup systems, and storage capabilities. The technology stack should be carefully chosen, considering scalability, performance, and integration requirements.

Software Development Life Cycle: A well-defined software development life cycle (SDLC) is crucial for the successful implementation of the hospital management system. This includes phases such as requirement analysis, system design, development, testing, deployment, and maintenance. Following a structured SDLC ensures proper planning, development, and quality assurance.

Data Management: The project requires a robust data management strategy to handle patient information, medical records, billing data, and other sensitive data. This includes data security measures, data backup procedures, and compliance with privacy regulations.

Vendor Selection: If the company decides to acquire a commercial off-the-shelf (COTS) hospital management system, a thorough evaluation of vendors and their offerings is necessary. This includes assessing features, functionality, scalability, support services, and pricing models.

Integration with Existing Systems: Many hospitals already have existing systems in place, such as laboratory information systems, radiology systems, and pharmacy systems. Integration of the hospital management system with these existing systems is critical for seamless data exchange and efficient operations.

Training and Change Management: Adequate training programs should be conducted to ensure that end-users, including healthcare professionals and administrative staff, are proficient in using the new system. Change management strategies should be implemented to facilitate a smooth transition from the old system to the new hospital management system.

Ongoing Support and Maintenance: Post-implementation, the company needs to provide ongoing technical support, system maintenance, bug fixes, and regular updates. This ensures the system's stability, performance, and adaptation to changing requirements.

Regulatory Compliance: The company should ensure that the hospital management system adheres to regulatory standards and guidelines, such as HIPAA (Health Insurance Portability and Accountability Act) or other applicable healthcare regulations. Compliance measures should be incorporated into the system design and functionality.

IV. PROPOSED SYSTEM

The proposed system in a hospital management system project refers to the solution or software that will be developed or implemented to automate and streamline various processes within the healthcare organization. It encompasses the core functionalities and features that aim to address the specific requirements and challenges identified during the project's planning phase.

The proposed system will work as a centralized platform to manage and integrate various aspects of hospital management, including:

Patient Registration and Management: The system will facilitate the registration and management of patient information, including demographics, medical history, allergies, and contact details. It will provide a centralized repository for storing and updating patient records.

Appointment Scheduling: The proposed system will enable efficient appointment scheduling, allowing patients to book appointments online or through other convenient channels. It will include features like automated reminders, rescheduling, and real-time availability of healthcare providers.

Electronic Medical Records (EMR): The system will capture, store, and manage electronic medical records, including diagnoses, treatments, prescriptions, test results, and progress notes. It will allow authorized healthcare professionals to access and update patient records in a secure and efficient manner.

Billing and Invoicing: The proposed system will handle billing and invoicing processes, generating accurate bills, tracking payments, and managing insurance claims. It will integrate with financial systems to ensure accurate and timely financial transactions.

Inventory Management: The system will include modules to manage medical supplies, equipment, and pharmaceuticals. It will track inventory levels, generate purchase orders, facilitate stock replenishment, and minimize wastage.

Reporting and Analytics: The proposed system will provide comprehensive reporting and analytics capabilities, generating various reports on patient statistics, financial performance, resource utilization, and other key performance indicators. It will allow hospital administrators to monitor and optimize operations.

Security and Access Controls: The system will incorporate security measures to protect patient data and ensure compliance with privacy regulations. This includes user authentication, role-based access controls, data encryption, audit trails, and regular security updates.

Integration with External Systems: The proposed system will facilitate integration with existing systems, such as laboratory information systems, radiology systems, and pharmacy systems. This integration will allow for seamless data exchange and interoperability between different departments.

User-Friendly Interface: The system will have a user-friendly interface that is intuitive and easy to navigate. It will prioritize usability, ensuring that healthcare professionals can quickly adapt to the system and perform their tasks efficiently.

The proposed system aims to streamline workflows, enhance patient care, optimize resource utilization, improve financial management, and ensure regulatory compliance. It will serve as a comprehensive tool to centralize and automate various administrative, operational, and clinical processes within the hospital, ultimately improving the overall efficiency and effectiveness of healthcare delivery.

V. FEASIBILITY STUDY

The feasibility of the project is analysed in this phase and business proposal is put forth with a very general plan for the project and some cost estimates. During system analysis the feasibility study of the proposed system is to be carried out. This is to ensure that the proposed system is not a burden to the company. For feasibility analysis, some understanding of the major requirements for the system is essential.

Technical Feasibility: This involves evaluating whether the proposed system can be developed or implemented using the available technology infrastructure, resources, and expertise. It assesses factors such as system scalability, integration with existing systems, and compatibility with hardware and software platforms.

Economic Feasibility: The economic feasibility study analyzes the financial implications of implementing the hospital management system. It assesses the costs associated with software development, hardware infrastructure, licensing, training, maintenance, and ongoing support. Additionally, it considers the potential benefits and return on investment (ROI) that the system can provide, such as improved efficiency, cost savings, and revenue generation.

Operational Feasibility: The operational feasibility study focuses on evaluating whether the proposed system aligns with the organization's operational processes, workflows, and objectives. It assesses the impact of the system on daily operations, staff workload, and user acceptance. It also considers factors such as the ease of implementation, training requirements, and potential disruptions during the transition.

Schedule Feasibility: The schedule feasibility study determines the project's timeline and evaluates if the proposed system can be implemented within the desired timeframe. It considers factors such as project complexity, resource availability, development and testing phases, and potential dependencies or risks that could impact the project schedule.

VI. PERFORMANCE EVALUATION

Define evaluation criteria: Clearly define the criteria against which you will evaluate the system. This may include factors such as functionality, usability, performance, scalability, data security, user satisfaction, and alignment with project objectives.

Gather feedback from stakeholders: Collect feedback from various stakeholders, including hospital administrators, doctors, nurses, staff members, and patients. Conduct surveys, interviews, or focus groups to understand their experiences, satisfaction levels, and any concerns or suggestions they may have regarding the system.

Assess system performance: Evaluate the system's performance based on predefined metrics and key performance indicators (KPIs). This may include analyzing response times, system availability, data accuracy, error rates, and system stability. Compare the actual performance with the defined performance targets.

Review system functionalities: Assess the functionality and features of the system against the defined requirements and expectations. Evaluate how well the system supports the hospital's operations and workflows. Identify any gaps or areas where the system falls short.

Analyse user adoption and satisfaction: Measure the level of user adoption and acceptance of the system. Assess user satisfaction through surveys or feedback mechanisms. Identify any challenges or barriers that may hinder user adoption and address them accordingly.

Review data integrity and security: Evaluate the system's data integrity and security measures. Assess if patient data is properly protected, data access controls are in place, and

data backups are performed regularly. Ensure compliance with relevant regulations and standards, such as HIPAA (Health Insurance Portability and Accountability Act).

Analyse system impact: Assess the impact of the hospital management system on various aspects of the hospital's operations. Consider factors such as efficiency improvements, cost savings, reduction in errors, streamlined workflows, and improved patient care. Compare the before-and-after scenarios to determine the system's overall impact.

Identify areas for improvement: Based on the evaluation findings, identify areas where the system can be improved or optimized. This may involve addressing user concerns, enhancing functionality, improving system performance, or refining processes. Prioritize the identified improvements based on their impact and feasibility.

Implement improvement measures: Develop an action plan to implement the identified improvements. Assign responsibilities and allocate resources accordingly. Implement necessary changes, updates, or enhancements to address the identified areas for improvement.

Monitor and reassess: Continuously monitor the system's performance and reassess its effectiveness over time. Track key metrics and KPIs to ensure the system continues to meet the evolving needs of the hospital. Gather regular feedback from stakeholders to identify new areas for improvement.

VII. CONCLUSION

The package was designed in such a way that future modifications can be done easily. The following conclusion can be deduced from the development of the project.

Automation of the entire system improves the efficiency

It provides a friendly graphical user interface which proves to be better when compared to the existing system.

It gives appropriate access to the authorized users depending on their permissions.

It effectively overcomes the delay in communications.

Updating of information becomes so easier.

System security, data security and reliability are the striking features.

The System has adequate scope for modification in future if it is necessary.

VIII. SYSTEM DESIGN

Hospital Management System is a web application for the hospital which manages doctors and patients. In this project, we use PHP and MySQL database.

The entire project mainly consists of 3 modules, which are

- Admin module
- User module
- Doctor module

A. ADMIN MODULE:

Admin can also change his/her own password. The admin module in a hospital management system project serves as the administrative control center of the system, providing functionality and tools for managing various aspects of the healthcare organization. It is typically designed for authorized personnel with administrative privileges, such as hospital administrators, department heads, and system administrators. The admin module encompasses several key features and responsibilities, including:

User Management: The admin module allows administrators to create and manage user accounts within the system. This includes adding new users, assigning roles and permissions, and maintaining user profiles. It ensures that access to different functionalities and data within the system is controlled and managed effectively.

System Configuration: Administrators can configure and customize the settings of the hospital management system. This includes setting up system preferences, defining organization-specific parameters, and adjusting system behavior according to the organization's needs. It allows administrators to tailor the system to match the workflows and requirements of the healthcare organization.

Master Data Management: The admin module enables administrators to manage the master data of the system. This includes maintaining information about departments, wards, doctors, nurses, staff members, medical procedures, treatments, medications, and other relevant entities within the organization. It ensures that the system's data is accurate, up-to-date, and reflects the organizational structure and resources.

Appointment and Schedule Management: Administrators can oversee and manage the appointment and schedule functionalities within the hospital management system. This includes managing doctors' schedules, allocating time slots for patient appointments, handling cancellations or rescheduling requests, and maintaining an overall view of the appointment calendar.

Reporting and Analytics: The admin module provides reporting and analytics tools for administrators to generate comprehensive reports and insights. This includes generating statistical reports on patient demographics, resource utilization, financial performance, and other key performance indicators. It enables administrators to monitor the organization's performance, identify trends, and make data-driven decisions.

System Maintenance and Upgrades: Administrators are responsible for system maintenance and ensuring its smooth operation. This includes monitoring system performance, handling backups and data recovery, applying software updates and patches, and managing system integrations. They are also responsible for coordinating with technical support or vendor teams if any technical issues arise.

Security and Access Control: The admin module includes features for managing system security and access control. Administrators can define user roles, permissions, and access levels, ensuring that sensitive information is accessible only to authorized personnel. They can enforce security measures such as password policies, user authentication mechanisms, and audit trails to protect patient data and maintain compliance with data privacy regulations.

System Audit and Logs: The admin module allows administrators to review system logs and audit trails. This helps in monitoring user activities, tracking system changes, and investigating any security breaches or unauthorized access attempts. It enhances the overall system security and facilitates compliance with regulatory requirements.

B. USER MODULE (PATIENT):

User can update his/her profile, change the password and recover the password.

Registration and Profile Management: The User module allows patients to register themselves in the system by providing their personal information, contact details, and demographic data. Once registered, patients can manage their profiles, update information, and maintain their medical history within the system.

Appointment Booking: Patients can use the system to book appointments with doctors or specific departments based on their medical needs. The module offers a user-friendly interface to view available time slots, select preferred doctors or healthcare professionals, and schedule appointments accordingly. Patients can also receive appointment confirmation notifications.

Access to Medical Records: The User module provides patients with secure access to their medical records, including diagnoses, treatment history, laboratory test results, prescriptions, and progress notes. It enables patients to review their healthcare information, track their medical history, and better understand their treatment plans.

Communication and Messaging: Patients can communicate with healthcare providers through the system's messaging feature. They can send inquiries, request prescription refills, seek clarifications, or exchange messages related to their medical conditions. This functionality facilitates convenient and secure communication between patients and healthcare professionals.

Prescription and Medication Management: Patients can access their prescriptions and medication information through the system. They can view prescribed medications, dosage instructions, and any necessary precautions. The module may also include features for requesting medication refills and tracking medication adherence.

Online Consultations (Telemedicine): If the hospital management system supports telemedicine capabilities, the User module allows patients to schedule and conduct virtual consultations with healthcare providers. Patients can have video or audio consultations, share medical records or test results, and receive remote medical advice or treatment.

Billing and Payment: Patients can view and manage their billing information through the system. This includes accessing invoices, checking payment statuses, and making online payments securely. The module may integrate with payment gateways to facilitate convenient and seamless transactions.

Health Education and Resources: The User module may offer health education resources, including articles, videos, and educational materials related to common medical conditions, preventive measures, and healthy lifestyle choices. It empowers patients with information to make informed healthcare decisions and improve their overall well-being.

Feedback and Ratings: Patients can provide feedback and ratings for healthcare services received through the system. This feedback helps in evaluating the quality of care and service provided by healthcare providers, enabling continuous improvement and patient satisfaction.

The User module (patient) aims to enhance the patient's engagement, convenience, and access to healthcare services. It empowers patients to actively participate in their healthcare journey, access information, and interact with healthcare providers efficiently. By leveraging the functionalities offered by this module, patients can

experience improved communication, seamless appointment management, and better access to their medical records and healthcare resources.

C. DOCTOR MODULE:

The Doctor module in a hospital management system project provides functionalities and tools specifically designed for healthcare professionals, including doctors, physicians, and specialists. The module aims to streamline and enhance their clinical workflow and improve patient care. Here are the key features and capabilities of the Doctor module:

Patient Management: The Doctor module allows doctors to access and manage patient records. They can view patient demographics, medical history, test results, diagnoses, treatment plans, and progress notes. This enables doctors to have a comprehensive overview of the patient's health information and make informed medical decisions.

Appointment Management: Doctors can manage their appointment schedules and view upcoming appointments. They can accept or reschedule appointments based on availability. The module may also include features for sending appointment reminders to patients.

E-Prescribing: Doctors can electronically prescribe medications to patients through the system. They can enter prescription details, including medication name, dosage, instructions, and any necessary precautions. E-prescribing improves accuracy, reduces medication errors, and enables seamless integration with the pharmacy system.

Clinical Documentation: The Doctor module provides tools for doctors to document patient encounters efficiently. They can create progress notes, record diagnoses, document treatment plans, and add relevant comments. The module may support templates and predefined forms to streamline documentation.

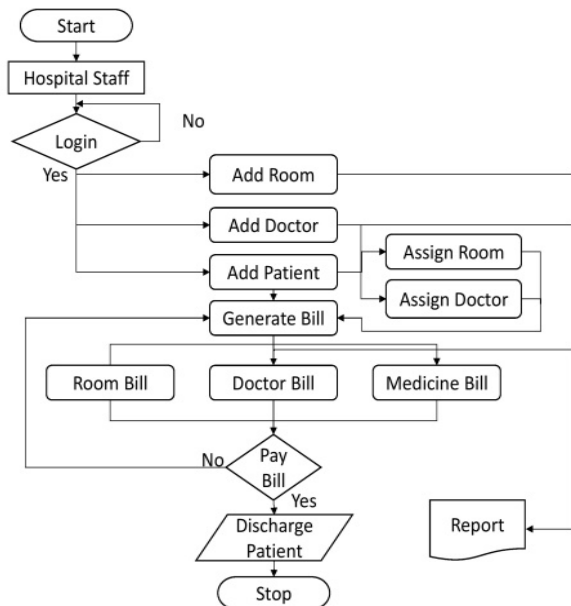
Order Management: Doctors can generate and manage various orders for diagnostic tests, laboratory investigations, imaging studies, and other procedures. They can place orders, view order statuses, and access the results once available. This helps doctors track patient progress and make informed decisions based on test outcomes.

Communication and Messaging: The module facilitates communication between doctors and other healthcare professionals within the hospital management system. Doctors can exchange secure messages, seek consultations, discuss patient cases, and collaborate with the care team.

Decision Support: The Doctor module may offer decision support tools, such as access to medical reference resources, clinical guidelines, drug interaction alerts, and allergy warnings. These tools assist doctors in making evidence-based decisions and ensuring patient safety.

Reporting and Analytics: Doctors can access reports and analytics generated by the hospital management system. This includes patient statistics, outcomes, quality measures, and performance indicators. The reports provide insights into the doctor's practice, patient populations, and aid in clinical research or quality improvement initiatives.

Referral Management: The module may include features for managing patient referrals to other specialists or departments within the healthcare organization. Doctors can initiate and track referrals, view referral statuses, and communicate with the referred healthcare professionals.



IX. FUTURE SCOPE

This application avoids the manual work and the problems concern with it. It is an easy way to obtain the information regarding the various travel services that are present in our System.

Well I and my team member have worked hard in order to present an improved website better than the existing one's regarding the information about the various activities. Still, we found out that the project can be done in a better way. Primarily, In this system patient login and then go to reception. By using this patient will send request for consulting the doctor. Reception will set the date for doctor appointments. After that doctor see his appointments and see the patients, surgeries also done.

The next enhancement is, we will develop online services. That mean, if patient have any problems he can send his problem to the doctor through internet from his home then doctor will send reply to him. In this patients have some login name and password.

X. REFERENCES

- [1] Anand, K., & Akundi, S. (2018). Hospital Management System: A Review. *International Journal of Advanced Research in Computer Science*, 9(2), 47-50.
- [2] Bagale, A. S., & Rane, S. R. (2017). Development of Hospital Management System for Small Size Hospital. *International Journal of Science and Research*, 6(10), 448-451.
- [3] Bhatnagar, R., Sharma, V., & Khatri, S. K. (2019). A Review of Hospital Management Systems in Developing Countries: Lessons Learned and Challenges Ahead. *Health Services Insights*, 12, 1178632919864701.
- [4] Desai, B., & Patel, S. (2018). Design and Development of Hospital Management System. *International Journal of Recent Trends in Engineering & Research*, 4(2), 120-123.
- [5] Jain, S., Kapoor, R., & Goyal, P. (2018). Implementation of Hospital Management System Using UML and Rational Rose. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 3(1), 452-456.
- [6] Kumar, N., & Singh, R. (2018). A Review Paper on Hospital Management System. *International Journal of Innovative Research in Computer Science and Technology*, 6(2), 33-37.
- [7] Patil, R. R., & Sharma, V. (2017). Design and Implementation of Hospital Management System. *International Journal of Computer Sciences and Engineering*, 5(2), 114-118.
- [8] Raza, N., & Raza, S. (2018). Hospital Management System: A Comprehensive Approach. *Journal of Advanced Research in Dynamical and Control Systems*, 10(03-Special Issue), 260-267.
- [9] Hejri, S. M., & Tofighi, S. (2016). A Survey on Hospital Management Systems. *Health Informatics Research*, 22(2), 74-80.
- [10] Rahimi, B., & Vimarlund, V. (2018). The Benefits and Challenges of Hospital Information Systems: A Systematic Review. *Journal of Medical Systems*, 42(4), 74.
- [11] Uzoka, F. M., Obagbuwa, I. C., & Kamalu, I. (2017). Hospital Information System: A Study of Electronic Medical Record Implementation at a Hospital in Nigeria. *Health Policy and Technology*, 6(3), 329-338.
- [12] Jha, A. K., DesRoches, C. M., Campbell, E. G., Donelan, K., Rao, S. R., Ferris, T. G., ... & Blumenthal, D. (2009). Use of Electronic Health Records in U.S. Hospitals. *New England Journal of Medicine*, 360(16), 1628-1638.
- [13] McAlearney, A. S., Sieck, C. J., Hefner, J. L., & Aldrich, A. M. (2016). High Touch and High Tech (HT2) Proposal: Transforming Patient Engagement Throughout the Continuum of Care by Engaging Patients with Portal Technology at the Bedside. *JMIR Research Protocols*, 5(4), e221.
- [14] Chae, Y. M., & Lee, S. G. (2018). Factors Influencing Successful Hospital Information System Implementation. *Health Informatics Journal*, 24(3), 197-209.
- [15] Kuo, K. M., & Sahama, T. (2016). A Hierarchical Decision Model for Evaluating Hospital Information Systems: A Case Study in Taiwan. *International Journal of Medical Informatics*, 87, 34-48.
- [16] Siponen, M., & Vartiainen, T. (2017). Health Care Professionals' Perceptions of the Effects of a Digital Registry System: Survey Study. *Journal of Medical Internet Research*, 19(12), e416.