Design of Web-Based Electronic Medical Record System Using User-Centered Design Method (Case Study: University of Mataram Hospital)

Khairunnisa Fitriani*, Santi Ika Murpratiwi, Moh. Ali Albar
Dept Informatics Engineering, University of Mataram
Jl. Majapahit 62, Mataram, Lombok NTB, INDONESIA
Email: khairunnisafitriani02@gmail.com, santiika@staff.unram.ac.id, mohalialbar@unram.ac.id
Corresponding Author

Abstract **The growing demand for integrated and secure medical documentation has driven hospitals to adopt Electronic Medical Record (EMR) systems. This study focuses on the design of a web-based EMR system for the University of Mataram Hospital using the User-Centered Design (UCD) approach. The design aims to overcome the limitations of existing systems, particularly those related to hospital workflows that hinder usability and adaptability. The EMR module is envisioned as part of a microservice-based Hospital Information System, integrating key functionalities such as patient data management, medical history tracking, referral and control letter generation, and dashboard summaries. The development process includes user analysis, UML modeling, and UI/UX prototyping. The resulting prototype is evaluated using the User Experience Questionnaire (UEQ) with direct feedback from hospital staff. The final system is expected to be better aligned with the operational workflows of University of Mataram Hospital, offering improved integration, usability, and adaptability compared to the previous system.**

Key words: **Electronic Medical Record, Web-Based System, User-Centered Design, Hospital Information System, UEQ**

I. INTRODUCTION

The Indonesian Ministry of Health has established strategies and regulations for the development of Hospital Management Information Systems (SIMRS) to support decision-making through the integration of service workflows [1]. However, the implementation of these regulations has not been optimal. Hospitals face challenges in improving service quality, reducing medical errors, accelerating information access, and controlling operational costs. SIMRS plays a crucial role in enhancing the efficiency and effectiveness of healthcare services through integrated data management, processing, and reporting, with medical records serving as a key module to support service quality [2].

Law Number 44 of 2009 mandates that hospitals manage medical records that systematically, chronologically, and accurately document patient data. To keep pace with technological developments, medical records have transitioned to electronic formats (Electronic Medical Records/EMR), enabling secure storage, fast access, and inter-module integration. The Ministry of Health Regulation No. 24 of 2022 mandates the implementation of EMR in all healthcare facilities; however, as of 2020, only 74 out of 575 hospitals in Indonesia had implemented it in an integrated manner, and even those were not fully optimized [3].

The University of Mataram Hospital has adopted the Khanza Hospital Management Information Systems to support its operations, including the management of medical records, with EMR integration beginning in mid-2024. SIMRS Khanza is an open-source Hospital Information Management System that has been widely adopted by various hospitals in Indonesia to support the digitalization of service workflows and hospital data management [4].

Using the Khanza System to integrate EMR aims to comply with regulations from the Ministry of Health and provide easier data access for medical personnel. Nevertheless, despite the significant benefits Khanza system offers in supporting hospital operations, the system has several shortcomings. One of its main weaknesses is the limited flexibility to adapt the system to the specific needs of the hospital [4]. Additionally, Khanza system's user interface is considered less attractive and not intuitive. Its built-in features are designed for general use, often requiring additional customization to fully support the workflow [5].

Based on interviews with the University of Mataram Hospital, several features in the Khanza System are not utilized by RS-UNRAM. The system's workflow is also not specifically tailored to match the actual processes within the hospital, including those in the medical records module. Although efforts have been made to integrate EMR using the Khanza System, not all medical record data can currently be captured electronically. Furthermore, the system still relies on Khanza's default server infrastructure.

Therefore, the development of a new electronic medical record system that better aligns with the needs of the University of Mataram Hospital is necessary. Optimizing EMR elements can improve the efficiency of smoother clinical workflows [6]. By implementing a custom-designed system, the University of Mataram Hospital can be more flexible in making updates and developments according to the hospital's operational needs without relying on third-party developers. The system will be designed using a User-Centered Design (UCD) approach. Systems designed using the UCD method tend to have high usability because they are more focused on user needs [7].

This new system is designed to introduce innovations such as the implementation of microservice architecture. To support this innovation, an additional method called Total Architecture Synthesis (TAS) is adopted. This method emphasizes a comprehensive understanding of the organization's structure, processes, and operational needs before the system architecture is formally designed [8]. In the context of the web-based EMR system, TAS plays a crucial role in supporting the design of a microservice-based architecture that ensures modular, flexible, and integrated data flows between hospital departments and services [9].

To evaluate the user experience of the developed EMR prototype, this study adopts the User Experience Questionnaire (UEQ) method. UEQ is a standardized evaluation tool designed to measure user perception through 26 items grouped into six key dimensions: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty[10]. These dimensions reflect both pragmatic and hedonic qualities of the system, offering a comprehensive view of how users feel before, during, and after interacting with the interface. UEQ has been widely used in various technology evaluations due to its ability to deliver quick yet insightful feedback on user satisfaction and system usability [11].

With this new system, the hospital not only can improve operational efficiency but also enhance the quality of healthcare services. The overall aim of this research is to improve the management information system of the University of Mataram Hospital, allowing it to continue developing as a friendly, professional, and high-quality healthcare provider.

II. Literature Review

A. Supporting Theories

This section outlines the key theoretical foundations that guide the development of the proposed system. It includes concepts such as Electronic Medical Records, Microservice Architecture, User Interface, User Experience, User-Centered Design, Total Architecture Synthesis, and User Experience Questionnaire. Each theory contributes to different aspects of system design ensuring a comprehensive and structured development process.

A.1. Electronic Medical Record (EMR)

Electronic Medical Records (EMR) are digital systems that record and manage patient information such as identity, anamnesis, physical and laboratory examination results, diagnoses, and medical actions, to support integrated, continuous, and high-quality healthcare services [12]. EMR functions not only as documentation but also as a secure data repository that can be accessed by authorized parties, supporting hospital management efficiency and compliance with regulations such as Ministry of Health Regulation No. 24 of 2022 [2]. The implementation of EMR improves patient satisfaction, documentation accuracy, data access speed, and reduces clinical errors, while also serving as an official legal document protected against misuse [13].

A.2. Microservice Architecture

Microservice architecture, a software development approach that breaks down large systems into small, independent services, offers a modern solution for EMR [14]. Each service handles a specific function, such as patient data management or reporting, enabling independent development, testing, and updates without disrupting the entire system. The advantages of microservices include high scalability, ease of maintenance, and cross-platform flexibility, all of which support efficient EMR data integration [15]. Research indicates that microservice-based systems deliver better operational performance compared to monolithic architectures, especially in healthcare systems that require fast and reliable data access [16].

A.3. User Interface and User Experience

User Interface (UI) and User Experience (UX) play a critical role in ensuring the EMR system is user-friendly. UI includes visual elements such as colors, typography, and layout, which influence user interaction with the application [17]. UX, as defined by the International Organization for Standardization (ISO), encompasses the user's emotions, perceptions, preferences, and responses before, during, and after system use. An intuitive UI and optimal UX enhance user satisfaction, reduce training time, and support efficient clinical workflows. Poor UI/UX design can lead to user errors, reducing the effectiveness of digital health systems [18]. Therefore, well-designed UI/UX is necessary to minimize errors and improve medical staff productivity.

A.4. User-Centered Design

User-Centered Design (UCD) is a design approach that focuses on users' needs and contexts, involving them actively through needs analysis, prototype testing, and feedback-based design iterations to create intuitive and efficient systems [19]. Systems designed using the UCD method tend to have high usability because they are more focused on user needs [7]. This demonstrates that UCD is an effective method for system design.

A.5 Total Architecture Synthesis (TAS)

Total Architecture Synthesis (TAS) is a system design methodology that combines requirement analysis, business process modeling, and architectural planning in an integrated and iterative manner [8]. It allows for a more structured and maintainable development process by aligning system architecture with organizational needs. TAS has been effectively applied in health information systems to support modular designs enabling better data integration and system scalability [9].

A.6. User Experience Questionnaire

The User Experience Questionnaire (UEQ) is a standardized instrument designed to measure the user experience of interactive products quickly and comprehensively. It consists of 26 items that capture six dimensions of user experience: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty. These dimensions cover both pragmatic qualities—such as ease of use and efficiency—and hedonic qualities, including how stimulating or innovative the product feels. The questionnaire has been validated in multiple studies and is available in several languages, ensuring its reliability and applicability across diverse user groups and contexts [10].

B. Related Research

The journal titled "Design of a Web-Based Outpatient Medical Record Information System at Klinik Sehat Margasari Bandung" explains the design of an electronic medical record (EMR) system intended to replace manual data management that previously relied on paper-based processes. Its main focus is to improve the efficiency of managing patient data, medical records, medication, transactions, and report generation. The study concludes that a web-based system can help the clinic prevent data loss, accelerate information retrieval, and enhance report accuracy. The final result is a computerized system that facilitates administrative processes and supports better decision-making in clinic management [20].

In the journal "Design and Implementation of General Outpatient Medical Records at Rimbo Medica Hospital", the authors investigate the process of designing and implementing a computerized medical record system for general outpatient services. The system aims to replace manual methods, which are prone to errors and data duplication. The application enables more efficient recording of patient data, storage of medical histories, and report generation. The study reports a 61.4% improvement in the efficiency of medical record staff, along with improved data accuracy and easier information access for hospital management [21].

The journal titled "Implementation of Payment Gateway API Using Microservice Architecture" discusses the use of microservice architecture to support the development of a Payment Gateway application. This approach breaks the system into small, independent services, each responsible for a specific function. The study highlights the advantages of microservices, including development flexibility, scalability, and ease of maintenance. Each service is designed to communicate via an API gateway, which acts as a connector between modules. By implementing microservices, the application can be updated more easily without affecting other services. The journal emphasizes the importance of microservice architecture in modern systems for ensuring operational efficiency and reliability [14].

III. Methodology

The methodology employed in this study combines two approaches: User-Centered Design (UCD) as the main framework and Total Architecture Synthesis (TAS) as a supporting method. UCD focuses on designing the system based on users' needs and interaction contexts, while TAS is applied to strengthen the architectural design, particularly in the context of microservice-based integration. These two methods are complementary, as both follow iterative and requirement-driven stages. Therefore, TAS is used to assist in defining robust UML models and integration strategies that align with the modular and scalable architecture envisioned for the web-based EMR system.

The method used in designing the web-based electronic medical record (EMR) information system at the University of Mataram Hospital is User-Centered Design (UCD). UCD is a system development approach aimed at building software or systems by focusing on user needs, usability, environment, tasks, and workflow in its interface design. UCD consists of four main stages: Specify the context of use, Specify user and organization requirements, Produce design solutions, and Evaluate design against user requirements [22].

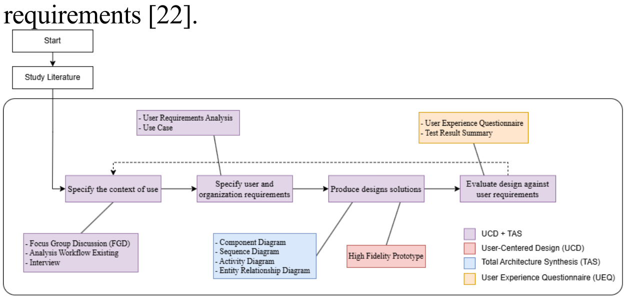


Fig. 1. Research Flow

Figure 1 presents the overall research flow that integrates the stages of User-Centered Design (UCD) and Total Architecture Synthesis (TAS). The UCD method consists of four main stages: (1) Specify the context of use, (2) Specify user and organizational requirements, (3) Produce design solutions, and (4) Evaluate designs against requirements. Meanwhile, TAS involves three key steps: (1) Requirement analysis, (2) Business process modeling, and (3) Architecture planning. In this study, UCD serves as the primary design approach, while TAS is applied to assist the architectural modeling process—particularly for generating UML diagrams and supporting the integration of microservices. The combination of these two methods, which share similar iterative structures, is illustrated in the flow of activities shown in Figure 1.

A. Study Literature

The literature study was conducted to collect relevant theories, best practices, and previous research findings related to the design of web-based Electronic Medical Record (EMR) systems. The study emphasized the importance of system usability, efficiency, and integration in hospital information systems (SIMRS). Furthermore, research on microservice architecture provided insights into the modular and scalable design of healthcare applications, which support independent development and deployment of system components.

B. Specify the Context of Use

This stage aims to understand the actual environment and circumstances in which the EMR system would be used. A series of qualitative methods were employed, including Focus Group Discussions (FGDs), analysis of existing workflows, and interviews with hospital staff. The FGD involved stakeholders from various modules of the hospital information system, such as registration, scheduling, pharmacy, and laboratory, to identify manual processes and challenges. The analysis of the existing system helped reveal limitations in terms of usability, system flexibility, and integration. Interviews further deepened the understanding of user pain points and operational needs. These combined insights provided a comprehensive view of the system's usage context and informed subsequent stages of development.

C. Specify User and Organizational Requirements

This stage focused on translating insights from the previous step into clear and actionable system requirements, such as identified various user roles within the hospital and their associated responsibilities and access levels Based on the findings from FGDs and interviews. This analysis was summarized in a table-mapping-user-types to their core tasks and system interactions. Furthermore, the requirements were visualized using a Use Case Diagram to depict system functionalities and interactions, as well as a Component Diagram to illustrate how the EMR system integrates with other modules within the hospital's information system. These diagrams served as a foundation for the design and development of a system tailored to the hospital's specific operational structure.

D. Produce Design Solutions

Once the requirements were established, the next step was to develop design solutions that addressed these needs. In this stage, the system design is developed based on the previously identified user and organizational requirements. Following the UCD approach, the focus is on creating a solution that aligns with real user needs and workflows, while the TAS method is used to strengthen the architectural modeling—particularly for microservice integration and secure modular design.

The design process involved creating several system modeling artifacts. The component diagram illustrates the modular structure of the EMR system within the broader SIMRS, showing how it interacts with other hospital modules. The sequence diagram describes the time-based interaction between users and the system, focusing on login and data integration processes. The activity diagram maps the workflow of creating a new medical record, including validation and conditional actions. The ERD (Entity Relationship Diagram) defines the system's database structure and highlights how data entities are related and integrated. Lastly, UI/UX artifacts such as wireframes and a high-fidelity prototype were developed to ensure the interface is intuitive, accessible, and aligned with the real needs of hospital staff.

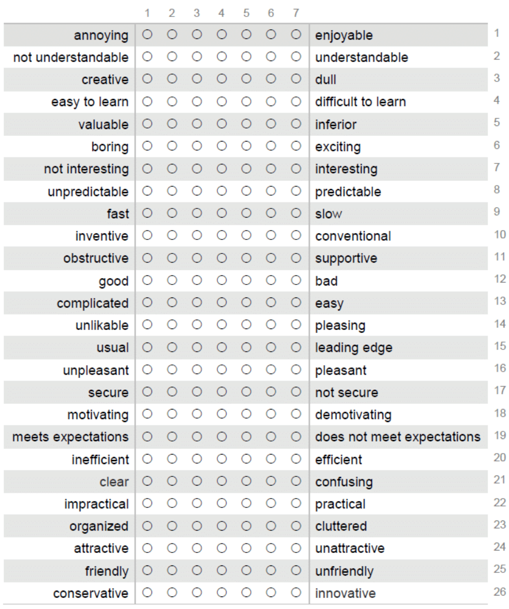
The integration of UCD and TAS in this stage ensures that both usability and system scalability are addressed in the design—making the system intuitive for users while maintaining robust internal architecture for future integration and expansion.

E. Evaluate Design Against User Requirement

This stage aims to test the developed High-Fidelity prototype to ensure the design meets the users' needs. The evaluation was conducted using the User Experience Questionnaire (UEQ), a validated tool that quickly measures user experience across multiple dimensions of interface quality.

E.1. User Experience Questionnaire (UEQ)

The UEQ consists of 26 items, as seen in figure 2, measuring six key dimensions of user experience: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty. This instrument enables users to express their impressions and feelings about the system in a simple and immediate way without requiring deep analysis or detailed recollection.



	1	2	3	4	5	6	7		
annoying	○	○	○	○	○	○	○	enjoyable	1
not understandable	○	○	○	○	○	○	○	understandable	2
creative	○	○	○	○	○	○	○	dull	3
easy to learn	○	○	○	○	○	○	○	difficult to learn	4
valuable	○	○	○	○	○	○	○	inferior	5
boring	○	○	○	○	○	○	○	exciting	6
not interesting	○	○	○	○	○	○	○	interesting	7
unpredictable	○	○	○	○	○	○	○	predictable	8
fast	○	○	○	○	○	○	○	slow	9
inventive	○	○	○	○	○	○	○	conventional	10
obstructive	○	○	○	○	○	○	○	supportive	11
good	○	○	○	○	○	○	○	bad	12
complicated	○	○	○	○	○	○	○	easy	13
unlikable	○	○	○	○	○	○	○	pleasing	14
usual	○	○	○	○	○	○	○	leading edge	15
unpleasant	○	○	○	○	○	○	○	pleasant	16
secure	○	○	○	○	○	○	○	not secure	17
motivating	○	○	○	○	○	○	○	demotivating	18
meets expectations	○	○	○	○	○	○	○	does not meet expectations	19
inefficient	○	○	○	○	○	○	○	efficient	20
clear	○	○	○	○	○	○	○	confusing	21
impractical	○	○	○	○	○	○	○	practical	22
organized	○	○	○	○	○	○	○	cluttered	23
attractive	○	○	○	○	○	○	○	unattractive	24
friendly	○	○	○	○	○	○	○	unfriendly	25
conservative	○	○	○	○	○	○	○	innovative	26

Fig. 2. User Experience Questionnaire

In this study, staff from the University of Mataram Hospital—including doctors, nurses, medical record admin, and administrative personnel—were asked to watch the video of web-based electronic medical record prototype. After watch the video, they completed the UEQ to provide feedback on the usability and user experience of the interface. The collected data were then analyzed to calculate average scores for each dimension and identify areas for improvement in subsequent design iterations.

E.2. Test Result Summary

The UEQ results were analyse to assess whether the prototype meets usability and user experience standards. Average scores for each dimension were compared with benchmark values derived from prior validation studies as seen in Table I, categorizing the outcomes as excellent, good, above average, below average, and bad. In addition to quantitative data, qualitative feedback from respondents was gathered to uncover suggestions and potential issues.

These findings provide valuable insights for refining the prototype, aiming to better meet the needs of hospital staff and support effective and efficient healthcare delivery.

TABLE I. BENCHMARK VALUES FOR UEQ

	Excellent	Good	Above Average	Below Average	Bad
Attractiveness	≥ 1,75	≥ 1,52 < 1,75	≥ 1,17 < 1,52	≥ 0,7 < 1,17	< 0,7
Perspicuity	≥1,9	≥ 1,56 < 1,9	≥ 1,08 < 1,56	≥ 0,64 < 1,08	< 0,64
Efficiency	≥1,78	≥ 1,47 < 1,78	≥ 0,98 < 1,47	≥ 0,54 < 0,98	< 0,54
Dependability	≥1,65	≥ 1,48 < 1,65	≥ 1,14 < 1,48	≥ 0,78 < 1,14	< 0,78
Stimulation	≥1,55	≥ 1,31 < 1,55	≥ 0,99 < 1,31	≥ 0,5 < 0,99	< 0,5
Novelty	≥1,4	≥ 1,05 < 1,4	≥ 0,71 < 1,05	≥ 0,3 < 0,71	< 0,3

IV. RESULT AND DISCUSSION

A. Study Literature

Theories and information related to the design of web-based EMR systems, User Interface (UI), User Experience (UX), the User-Centered Design (UCD) method and Total Architecture Synthesis method gather through study literature. The literature includes journals, books, and previous research relevant to UCD and TAS implementation in web-based information system development. Theories and information about evaluation methods such as the User Experience Questionnaire (UEQ) also reviewed to support appropriate usability testing of the system.

In addition, this section collects information related to the use of the Khanza Hospital Management Information System, in order to gain a better understanding of the system previously used by the University of Mataram Hospital. This study aims to explore best practices in designing an integrated web-based EMR system that offers improved integration, usability, and adaptability compared to the prior system.

B. Specify the Context of Use

This stage aims to understand the system usage context at the University of Mataram Hospital by collecting data on operational processes, user needs, and challenges. Main methods used are Focus Group Discussion (FGD), analysis workflow existing, and interviews.

B.1. Focus Group Discussion (FGD)

The FGD was conducted to collect qualitative data through group discussions. The session was attended by the entire development team of the University of Mataram Hospital Information System, including the registration module, scheduling module, inpatient module, pharmacy module, laboratory module, and payment module. In addition to the development team, discussions were also held with stakeholders from the University of Mataram Hospital side. The discussion aimed to identify processes such as patient registration, medical record management, and healthcare scheduling that were still carried out manually, as well as the challenges encountered in those processes. The FGD provided valuable insights into service workflows, system requirements, and user expectations for the EMR system.

B.2. Analysis Workflow Existing

Analysis workflow existing involved understanding the hospital information system previously used, namely Khanza Hospital Management Information Systems. The system was examined through documentation provided by the hospital to identify parts of the existing system that required changes or improvements. The analysis focused on limitations in user experience, flexibility, and system integration. These findings guided the redesign of the EMR module to better align with current user needs and hospital workflow requirements.

B.3. Interviews

Interviews were conducted to deepen the FGD findings by gathering more detailed information on the hospital's operational history, organizational structure, service workflows, medical record documentation processes, and specific challenges faced by staff. The interviews involved the same participants as the FGD and were conducted concurrently for efficiency. Additional insights were obtained from hospital staff during the interviews, including details about their workflow patterns, available healthcare services, and the scope of responsibilities handled by the medical records team. The results were used to map out specific system requirements.

C. Specify User and organization Requirements

This stage aims to formulate user and organizational needs based on data gathered from the FGD and interviews. These requirements are visualized using a Use Case Diagram to illustrate the interactions between users and the system.

C.1. User Requirements Analysis

To ensure that the EMR system meets the real needs of its users, an analysis of user roles, access levels, and responsibilities was carried out. This analysis helps to define the functional scope of the system based on what each type of user needs to do in their daily workflow. The following Table II summarizes the main user groups of the system, their access privileges, and their key tasks.

TABLE II. SUMMARY OF USER ROLES AND RESPONSIBILITIES

User Role	Access Level	Key Tasks
Medical Records Admin	Full system access	Create/edit records, print documents, generate reports
Doctor	View & update clinical records	Add diagnosis, prescriptions, actions
Nurse	View records and update nursing data	Input vitas signs, nursing assessments
Administrative Staff	Limited access to administrative functions	Create new records, issue control/referral letters

C.2. Use Case Diagram

The Use Case Diagram was developed to map the main functions of the EMR system, such as patient registration, patient data management, medical staff data management, medical record documentation, and healthcare service scheduling. Diagram in figure 3 illustrates the actors (hospital staff such as admins, doctors, and nurses) and their interactions with the system to meet the hospital's operational needs.

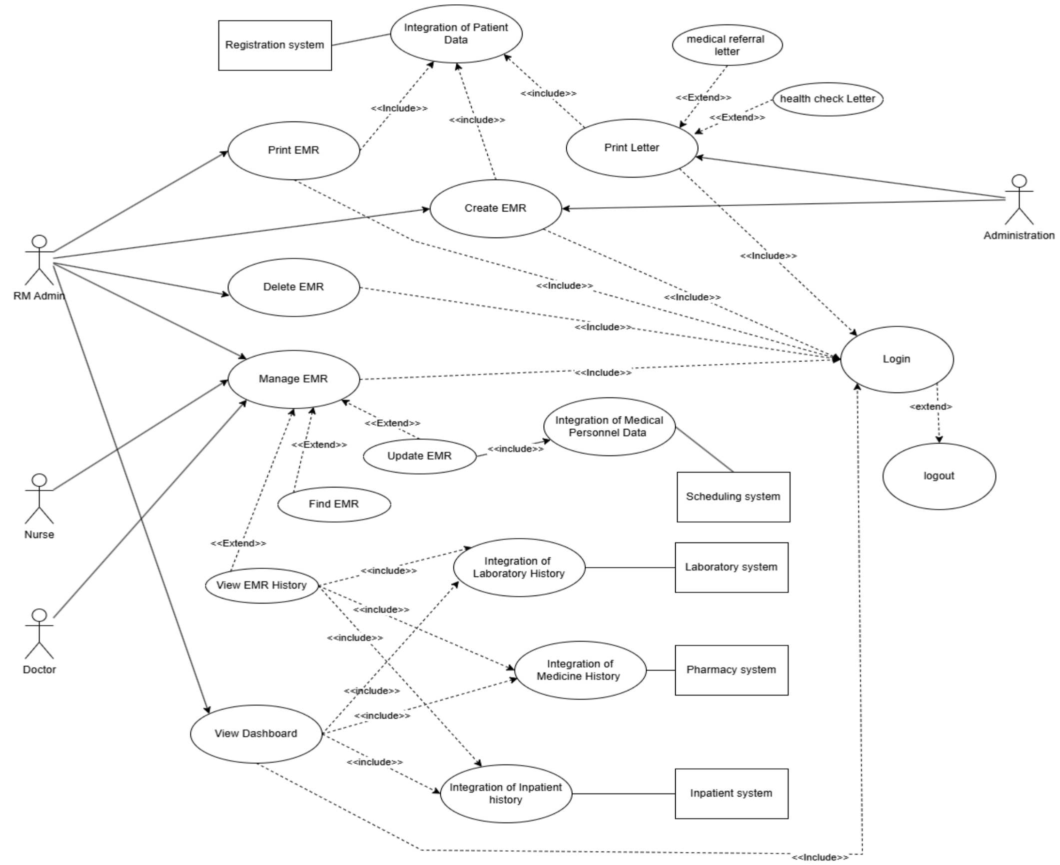


Fig. 3. Use Case Diagram [Link Use Case]

D. Produce Design Solutions

Design solutions are created based on the identified requirements. These include the development of a component diagram, sequence diagram, activity diagram, Entity Relationship Diagram (ERD), to produce a responsive High-Fidelity prototype tailored to user needs.

D.1 Component Diagram

To describe how the EMR system integrates within the larger Hospital Information System (SIMRS), a component diagram was developed. This diagram illustrates the structural organization of the Medical Record Service as a microservice and its interactions with both internal modules and external services.

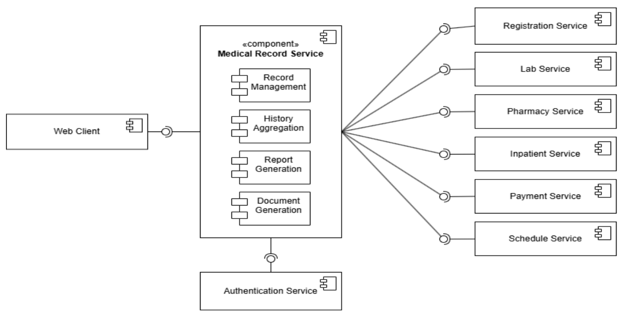


Fig. 4. Component Diagram [Link Component Diagram]

As seen in figure 4, the component diagram illustrates the modular structure of the Medical Record Service within the hospital's SIMRS, following a microservice architecture. The main component, Medical Record Service, is divided into several internal functions: Record Management, History Aggregation, Report Generation, and Document Generation. This service interacts with multiple external modules—such as Registration, Laboratory, Pharmacy, Inpatient, Payment, and Schedule Services—allowing for flexible and scalable integration across the hospital's operational units.

The component diagram demonstrates how the Medical Record Service is integrated with various other modules to support comprehensive and up-to-date patient records. The Pharmacy Service provides access to medication history, which is aggregated and displayed within the patient's medical record. The Laboratory Service supplies lab examination results to be included in the patient's clinical history. The Registration Service delivers patient demographic data required for generating new medical records, as well as for issuing referral and control letters. The Inpatient Service contributes treatment history that is essential for tracking patient care during hospital stays. Meanwhile, the Schedule Service provides information about assigned doctors and nurses, which is used to assign responsible personnel in medical record entries. Lastly, the Payment Service retrieves treatment and medication history from the medical record to calculate billing details. These integrations ensure that the EMR system supports centralized, real-time, and cross-functional data exchange, enhancing both clinical accuracy and operational efficiency.

The Web Client component serves as the user interface layer that connects users (e.g., medical staff, admin) to the system, while the Authentication Service ensures that only authorized users can access the system's functionality. This component plays a critical role in maintaining data security and privacy, by verifying user credentials before permitting access to sensitive patient information. It supports secure access control and prevents unauthorized interactions between services, which is especially crucial in handling confidential medical records.

D.2 Class Diagram

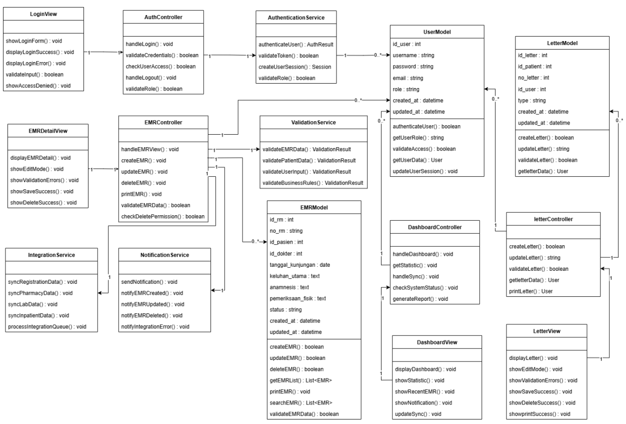


Fig. 5. Class diagram medical record [Link Class Diagram]

Figure 5 shows class diagram that illustrates the structure of the web-based Electronic Medical Record (EMR) system, consisting of several main components such as Login View, Auth Controller, Authentication Service, UserModel, EMRController, EMRDetailView, Validation Service, Integration Service, Notification Service, and EMRModel. This diagram describes the relationships and responsibilities of each class in managing user authentication, EMR data processing, integration with other services (such as laboratory and pharmacy data), and notifications related to EMR activities.

D.3. Sequence Diagram

The Sequence Diagram, as seen in figure 6, illustrates the time-ordered interactions between objects or actors involved in the process of updating medical record. It shows the communication steps between users and the system, from selecting patient to saving the record in the database. This diagram helps visualize the workflow and ensures that each step and interaction align with system requirements.

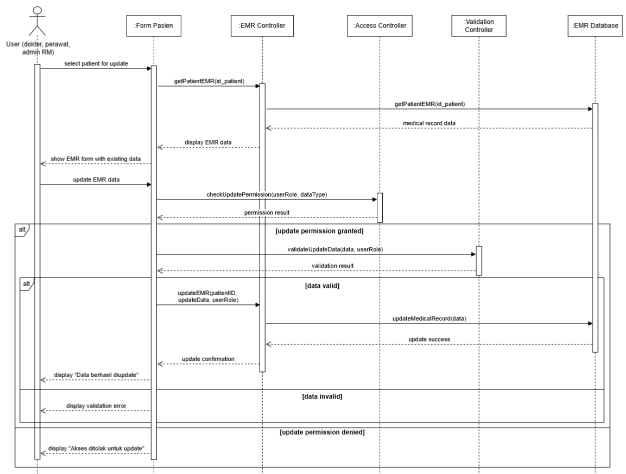


Fig. 6. SD update medical record [Link Sequence Diagram]

D.4. Activity Diagram

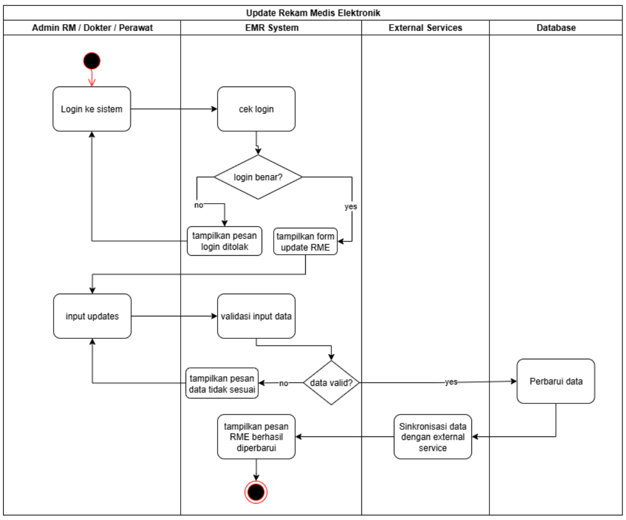


Fig. 7. Workflow update medical record [Link Activity Diagram]

The Activity Diagram, as seen in figure 7, depicts the detailed workflow of creating a new medical record, representing activities performed sequentially or in parallel. It maps out the user and system actions including data validation, form completion, and save confirmation. This diagram facilitates understanding of the business process and helps identify decision points and alternative paths within the workflow.

D.5. Entity Relationship Diagram (ERD)

The ERD, as seen in figure 8, is designed to map the database structure of the EMR system. It includes entities such as Patients, Medical Staff, Medical Records, and other Services, as well as the relationships between these entities. This ensures structured data storage and quick system access.

The Entity Relationship Diagram (ERD) illustrates the structure of the Medical Record module and its integration with several external modules within the hospital's SIMRS. Rather than redefining external data structures, the diagram incorporates referential connections to entities managed by other services, such as Registration, Scheduling, Laboratory, Inpatient Care, and User Management. These external entities—indicated in boxed sections—represent the original ERDs of other microservices, which are accessed by the Medical Record module for data consistency and interoperability.

For instance, patient demographic data is retrieved from the Registration module, medication and lab results are fetched from the Pharmacy and Laboratory modules, and doctor or nurse assignments are sourced from the Scheduling module. The Inpatient Care module provides vital signs and treatment histories, which are aggregated into the patient's medical record. This design reflects a service-oriented architecture where the EMR module acts as a consumer of external clinical and administrative data, enabling real-time integration without data duplication, while preserving data ownership within each microservice.

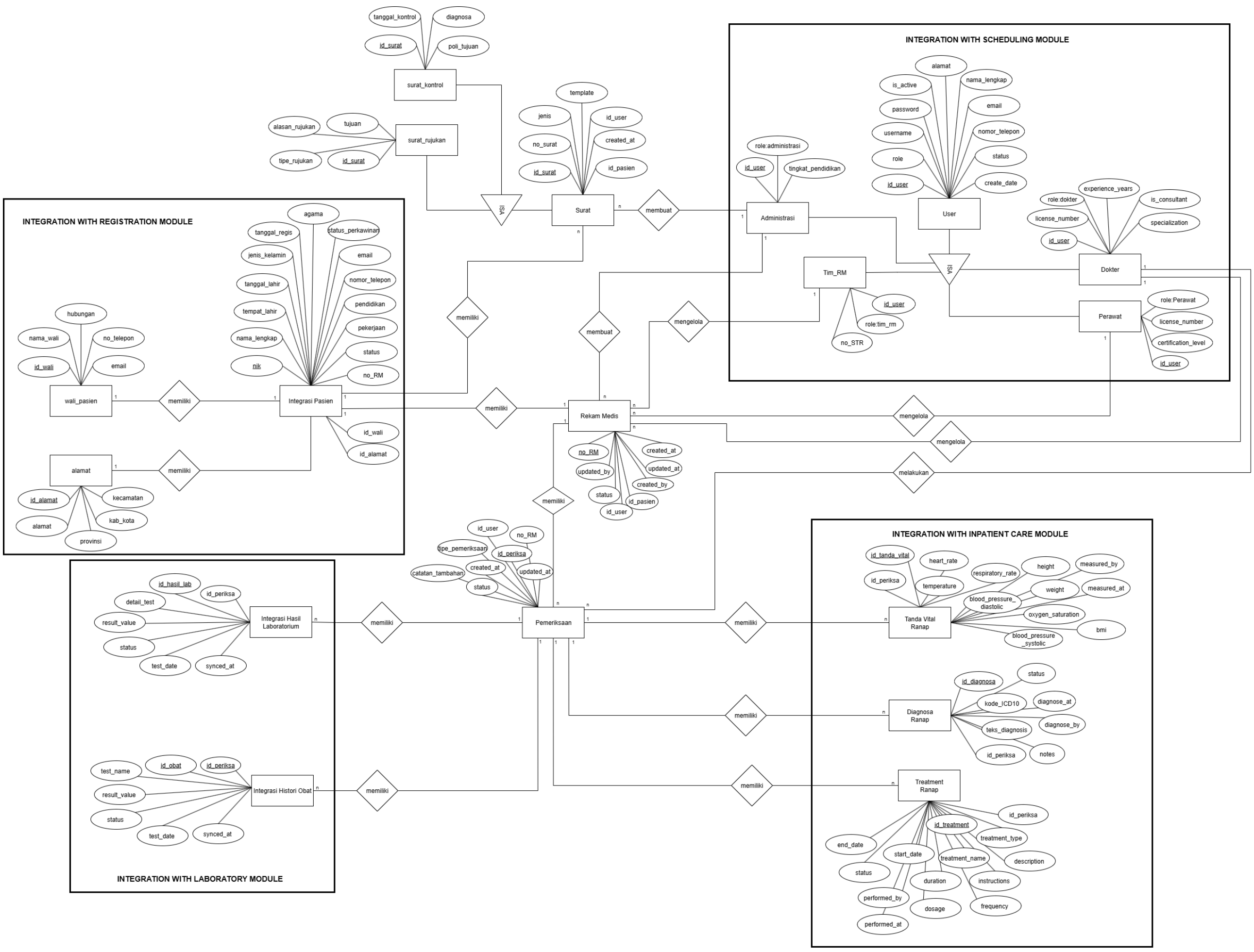


Fig. 8. Medical Record ERD [Link ERD]

D.6. UI/UX Design

The final stage in the design of the EMR system is the UI (User Interface) and UX (User Experience) design. The design of the EMR system was carried out with a strong focus on usability and experience to ensure that the system meets the needs of the healthcare staff while remaining intuitive and easy to use. The user interface (UI) and experience were developed using a User-Centered Design (UCD) approach, which ensured that the design process was driven by the real needs of users, including medical record administrators, doctors, nurses, and administrative staff. Two main design components were developed are the Dashboard and the Patient Profile.

Figure 9 shows Medical Record Dashboard. The Dashboard serves as the central hub for administrative users, providing an overview of key metrics such as the number of medical records created, the most common diagnoses, and quick access to essential functions like record creation and report generation. The design prioritizes clarity and ease of use by incorporating interactive charts and tables to display patient statistics and diagnoses, along with filters that allow users to narrow down data by time, gender, or type of medical condition. Quick navigation is also provided to create or search for patient records, monthly report, annual report, and print medical reports.

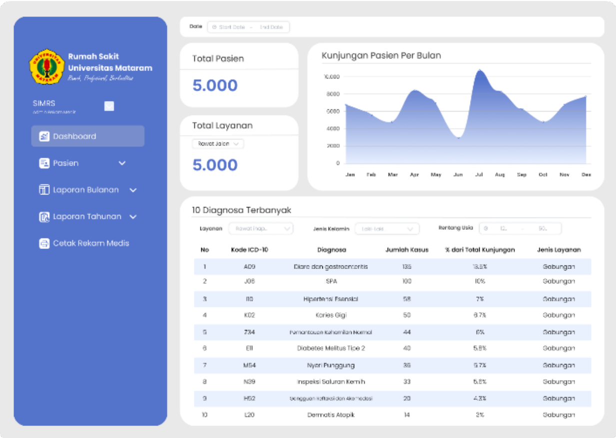


Fig. 9. Medical Record Dashboard

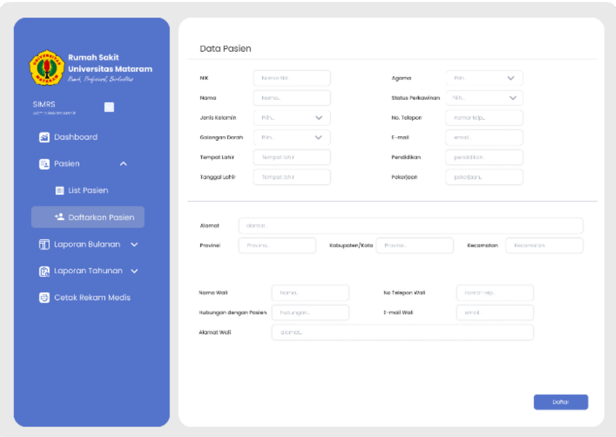


Fig. 10. Create New Patient

Figure 10 shows Create New Patient page, designed for registering new patients who do not yet have an existing medical record. The page includes a structured form where administrative staff can input essential patient information such as full name, date of birth, gender, address, and other relevant identification details. Upon submission, the system automatically generates a unique Medical Record Number for the patient and stores it securely in the database.

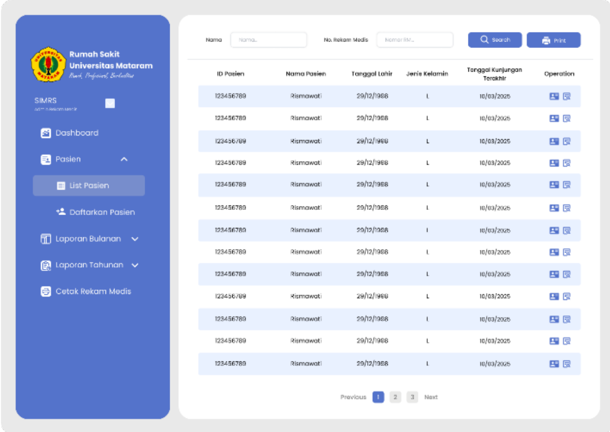


Fig. 11. Patient List

Figure 11 shows Patient List page, which displays a comprehensive list of all patients registered in the system. Each entry provides key summary data including the patient's name, date of birth, gender, and the date of their last visit. The interface is designed to support efficient navigation, featuring search and sorting capabilities, along with an operation button that allows users to access a patient's full profile. By clicking the profile button, medical staff can view detailed medical history, including diagnoses, laboratory results, prescriptions, and treatment records. This functionality enhances clinical workflow by providing quick and structured access to critical patient data.

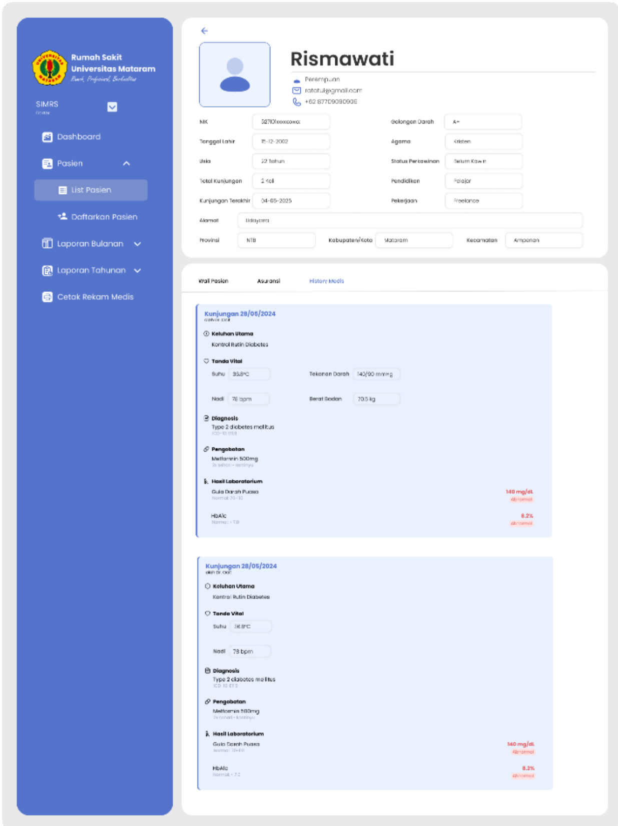


Fig. 12. Patient Profile Design

Figure 12 shows Patient Profile page offers a detailed view of individual patient histories, including vital signs, diagnoses, lab results, and prescriptions. The design allows healthcare professionals to quickly access comprehensive patient information in one place. Key features include tabs to organize data into sections such as vital signs, diagnoses, lab results, and prescriptions, as well as a timeline view to visualize the progression of diagnoses, treatments, and vital statistics over time. A searchable history feature is also included for easy access to past medical events.

Figure 13 shows Monthly Report page, which displays the number of patient visits segmented by department (poli) for a selected month. The report provides an overview of total patient visits per department, allowing medical records administrators to select a specific monthly range to view relevant data. In addition to department-wise statistics, the report module also includes various other breakdowns, such as patient visits per doctor, new vs. returning patients, gender distribution, patient types, patient types by department, and service status. These reports are available in both monthly and annual formats, supporting operational monitoring, trend analysis, and healthcare service evaluation.

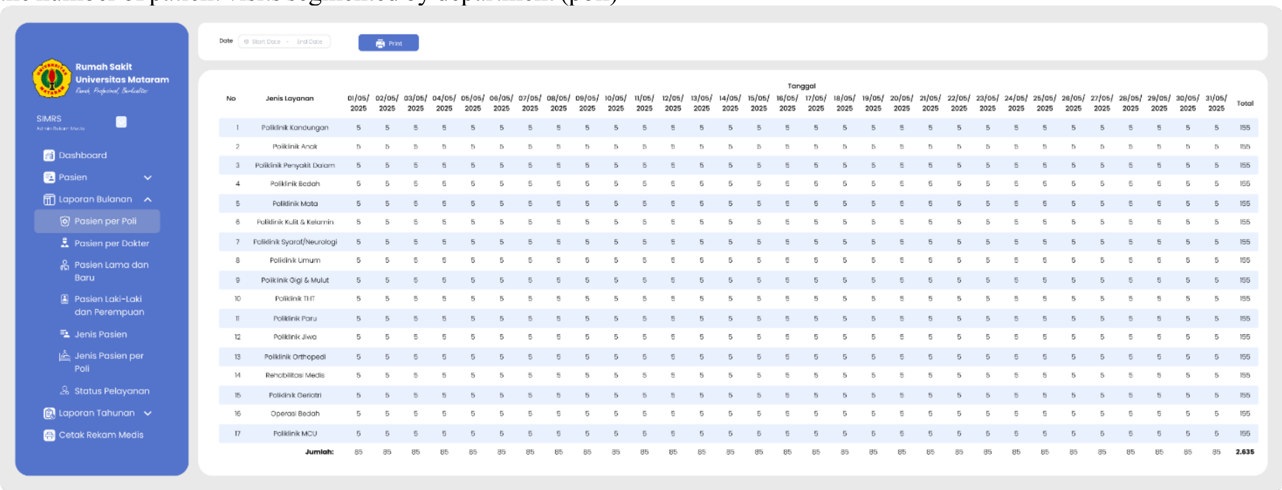


Fig. 13. Monthly Report Patient per Poli

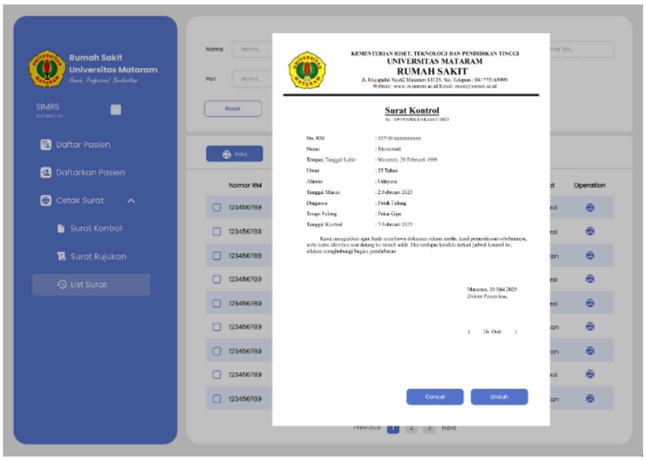


Fig. 14. Print Letter

Figure 14 shows the Print Letter page, which lists control or referral letters that can be accessed and managed by the administrative staff. Before a letter can be printed, the administrator must first create the referral or control letter and save it to this list. Once the letter is saved, it becomes available for printing directly from the Print Letter interface. This feature streamlines administrative workflows by consolidating letter creation, storage, and output into a centralized and accessible interface.

Figure 15 shows Update Diagnose page, which displays a list of medical records for patients. It is primarily intended for use by doctors and nurses who need to review a patient's medical history or update previously recorded diagnoses. The interface includes key information such as patient name, age, attending physician, appointment schedule, target department, diagnosis description, and ICD code. For a more detailed view of a patient's examination history, users can click on the profile button in the operations column. This feature is designed to support clinical decision-making by providing easy access to comprehensive and editable medical data.

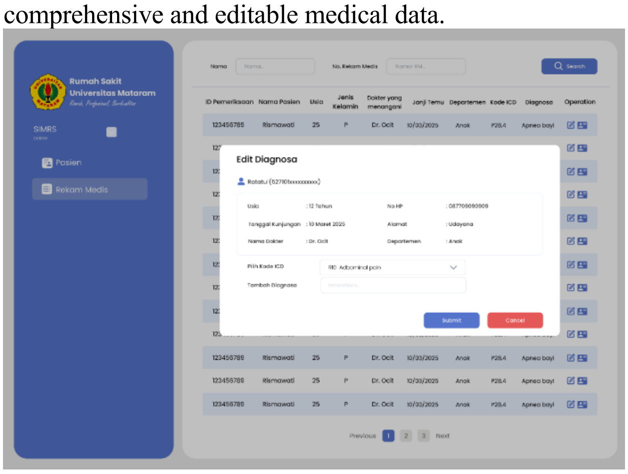


Fig. 15. Update Diagnose

E. Evaluate Design Against User Requirement

This stage aims to test the developed High-Fidelity prototype to ensure the design meets the users' needs. In this stage, staff from the University of Mataram Hospital—including doctors, nurses, medical record admin, and administrative personnel—were asked to watch the video of web-based electronic medical record prototype. After watch the video, they completed the UEQ to provide feedback on the usability and user experience of the interface.

E.1. User Experience Questionnaire (UEQ)

Items																									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
7	7	1	1	1	7	7	7	1	1	7	1	7	7	7	7	1	1	1	7	1	7	1	1	1	7
6	7	1	1	1	7	7	6	2	2	7	1	7	6	7	6	1	2	2	6	1	6	2	1	2	7
5	6	2	3	4	5	5	6	2	2	5	2	6	5	6	6	3	3	2	6	2	4	2	2	2	6
6	7	3	2	3	6	6	6	3	2	6	2	6	6	6	6	2	2	2	5	2	5	2	2	3	6
5	6	3	4	2	6	4	5	4	4	6	2	4	5	4	5	3	2	3	6	2	6	2	3	2	4
5	5	2	3	3	6	7	6	3	3	7	1	5	6	4	6	2	3	3	4	2	7	1	4	2	7
6	7	1	1	2	6	7	6	2	2	6	1	6	6	5	6	1	2	2	7	3	6	1	2	1	7
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
6	6	1	1	1	6	6	6	3	1	6	1	7	5	6	5	2	1	2	7	1	5	1	2	3	6
6	7	4	2	3	7	5	4	3	2	6	2	6	7	5	5	3	2	3	6	4	6	2	1	2	5
6	7	2	2	4	7	6	6	4	3	7	2	7	5	5	7	4	3	1	5	2	7	2	2	1	7
7	4	4	4	2	4	4	4	2	2	7	2	7	7	6	6	2	2	2	6	3	5	2	4	3	5
5	5	3	3	4	4	5	5	4	2	5	2	5	6	5	5	2	3	2	6	2	6	3	2	2	5
6	7	2	3	3	4	6	5	2	2	6	1	5	7	5	7	3	2	3	6	1	5	1	1	2	7

Fig. 16. Questionnaire Data

Figure 16 shows feedback from University of Mataram Hospital's Staff. From the form distributed to each user, 14 feedbacks were obtained. Each feedback consists 26 bipolar adjective pairs rated on a 7-point Likert scale. Each row represents a single respondent's complete answer set, capturing their initial impressions of the system's usability and overall user experience as seen in fig. 15. This dataset forms the foundation for all subsequent analysis stages, including transformation and dimensional grouping.

Figure 17 shows the data that has been converted from the original 1–7 scale responses into the UEQ standard scale of -3 to +3. Positively worded items are converted using the formula (value - 4), while negatively worded items are transformed using (4 - value). This normalization allows for a unified interpretation across dimensions and aligns with international UEQ benchmarks. The transformed data are then ready for grouping and averaging per user experience scale.

Items																									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	3	3	3	3	3	3	2	2	2	3	3	3	2	3	2	3	2	2	2	3	2	2	3	2	3
1	2	2	1	0	1	1	2	2	2	1	2	2	1	2	2	1	1	2	2	2	0	2	2	2	2
2	3	1	2	1	2	2	2	1	2	2	2	2	2	2	2	2	2	2	1	2	1	2	2	1	2
1	2	1	0	2	2	0	1	0	0	2	2	0	1	0	1	1	2	1	2	2	2	2	1	2	0
1	1	2	1	1	2	3	2	1	1	3	3	1	2	0	2	2	1	1	0	2	3	3	0	2	3
2	3	3	3	2	2	3	2	2	2	2	3	2	2	1	2	3	2	2	3	1	2	3	2	3	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	3	3	3	2	2	2	1	3	2	3	3	1	2	1	2	3	2	3	3	1	3	2	1	2
2	3	0	2	1	3	1	0	1	2	2	2	2	3	1	1	1	2	1	2	0	2	2	3	2	1
2	3	2	2	0	3	2	2	0	1	3	2	3	1	1	3	0	1	3	1	2	3	2	2	3	3
3	0	0	0	2	0	0	0	2	2	3	2	3	3	2	2	2	2	2	2	1	1	2	0	1	1
1	1	1	1	0	0	1	1	0	2	1	2	1	2	1	1	2	1	2	2	2	2	1	2	2	1
2	3	2	1	1	0	2	1	2	2	2	3	1	3	1	3	1	2	1	2	3	1	3	3	2	3

Fig. 17. Transformed Data

After transformed the data, next step is to calculate the averages scores based on the six UEQ scales: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty. To assist with the calculation, the 26 questions are grouped according to these six UEQ scales. Fig. 18 illustrates the distribution of each question into the corresponding scale.

Item	Left	Right	Scale
1	annoying	enjoyable	Attractiveness
2	not understandable	understandable	Perspicuity
3	creative	dull	Novelty
4	easy to learn	difficult to learn	Perspicuity
5	valuable	inferior	Stimulation
6	boring	exciting	Stimulation
7	not interesting	interesting	Stimulation
8	unpredictable	predictable	Dependability
9	fast	slow	Efficiency
10	inventive	conventional	Novelty
11	obstructive	supportive	Dependability
12	good	bad	Attractiveness
13	complicated	easy	Perspicuity
14	unlikable	pleasing	Attractiveness
15	usual	leading edge	Novelty
16	unpleasant	pleasant	Attractiveness
17	secure	not secure	Dependability
18	motivating	demotivating	Stimulation
19	meets expectations	does not meet expectations	Dependability
20	inefficient	efficient	Efficiency
21	clear	confusing	Perspicuity
22	impractical	practical	Efficiency
23	organized	cluttered	Efficiency
24	attractive	unattractive	Attractiveness
25	friendly	unfriendly	Attractiveness
26	conservative	innovative	Novelty

Fig. 18. Scale Distribution

Figure 19 below display the average score of each UEQ scale per respondent, allowing a user-level assessment of perceived experience. Each column corresponds to a UEQ dimension, while each row represents an individual participant. This visualization provides insight into how consistent or varied the system's experience is across different types of users.

Scale means per person					
Attractiveness	Perspicuity	Efficiency	Dependability	Stimulation	Novelty
3,00	3,00	3,00	3,00	3,00	3,00
2,33	3,00	2,00	2,50	2,75	2,75
1,67	1,75	1,50	1,50	0,75	2,00
1,83	2,25	1,25	2,00	1,75	1,75
1,33	1,00	1,50	1,25	1,50	0,25
1,67	1,25	1,75	2,00	1,75	1,50
2,33	2,25	2,50	2,25	2,25	2,25
0,00	0,00	0,00	0,00	0,00	0,00
1,67	2,75	2,00	2,00	2,50	2,50
2,17	1,75	1,75	1,00	1,75	1,00
2,17	2,50	1,50	2,00	1,50	1,75
1,83	1,00	1,75	1,75	1,00	1,25
1,67	1,25	1,25	1,50	0,50	1,25
2,67	2,00	2,00	1,25	1,25	2,00

Fig. 19. Scale Means per Person

UEQ Scales (Mean and Variance)		
Attractiveness	1,970	0,65
Perspicuity	1,839	0,76
Efficiency	1,443	0,69
Dependability	1,614	0,55
Stimulation	1,511	0,84
Novelty	1,693	0,73

Fig. 20. UEQ Scale Result (Mean and Variance)

Figure 20 summarizes the statistical results for each of the six UEQ dimensions, presenting both mean and variance values. The mean indicates the overall perception of the system for each scale, while the variance helps assess the consistency of responses. For instance, a high mean with low variance on the Efficiency scale suggests that most users found the system consistently effective and easy to use.

E.2. Test Result Summary

To evaluate whether the EMR prototype meets user expectations in terms of usability and user experience, the User Experience Questionnaire (UEQ) was utilized. The results obtained from the respondents were analyzed across six standardized dimensions: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty.

As seen in Table III, each dimension's average score was compared with the UEQ benchmark classification, which categorizes values into five levels: Excellent, Good, Above Average, Below Average, and Bad.

TABLE III. UEQ RESULT

Dimension	Average Score	Benchmark Category
Attractiveness	1.97	Excellent
Perspicuity	1.84	Good
Efficiency	1.44	Above Average
Dependability	1.61	Good
Stimulation	1.51	Good
Novelty	1.69	Excellent

The benchmark of the UEQ test results can be seen in figure 21 below:

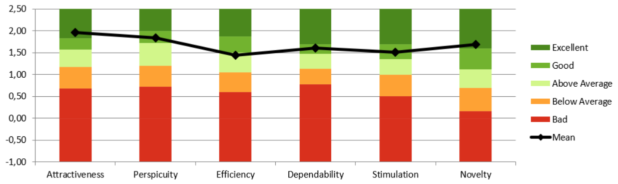


Fig. 21. UEQ Benchmark

The highest score was obtained in the Attractiveness dimension (1.97), indicating that users perceived the interface to be visually appealing, modern, and well-designed. Similarly, Novelty (1.69) achieved an Excellent rating, reflecting that the system was perceived as innovative and fresh.

On the pragmatic side, Perspicuity (1.84) and Dependability (1.61) scored within the Good range, suggesting that users found the system easy to understand and reliable. Meanwhile, Efficiency received a score of 1.44, which falls into the Above Average category. Although it did not reach the Good benchmark, the result still reflects generally positive usability and productivity perception, while also identifying an area with potential for improvement.

The Stimulation dimension scored 1.51, indicating the system was sufficiently engaging and motivating for users, though just below the threshold for Excellent.

Taken together, these results show that the system provides a well-rounded and satisfying user experience, especially in its visual design, innovation, and clarity, while still offering room for improvement in terms of task efficiency. These findings provide empirical support for the system's design choices and confirm the effectiveness of the User-Centered Design (UCD) methodology applied throughout development.

V. CONCLUSION AND RECOMMENDATION

A. Conclusion

This study presents the design and evaluation of a web-based Electronic Medical Record (EMR) system for the University of Mataram Hospital, addressing limitations found in previously used systems such as SIMRS Khanza. The proposed system was developed using the User-Centered Design (UCD) method, ensuring that the entire process—ranging from requirements analysis to prototyping and usability testing—involved real users, including doctors, nurses, administrative staff, and medical record personnel.

In terms of architectural design, the system applies a microservice-based approach, as modeled in the UML diagrams. This architecture allows each service to operate independently, minimizing system-wide failure when one component experiences an issue. For example, if the laboratory service is temporarily offline, other services—such as patient registration or record management—can continue functioning. This modularity not only improves fault isolation and system security, but also facilitates easier maintenance, updates, and future integration with other hospital departments, aligning with best practices in healthcare system design.

Evaluation using the User Experience Questionnaire (UEQ) revealed high scores across all six dimensions: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty. The system achieved a mean score above 1.5 in most dimensions, placing it in the Good to Excellent benchmark categories. These results confirm that the developed EMR prototype not only meets functional expectations but also provides a highly usable and satisfactory experience for healthcare professionals.

B. Recommendation

To further enhance the system's usability and effectiveness, several improvements are recommended. First, it is important to implement advanced filtering options on key pages such as the Patient List and Monthly Report. These filters would allow users to sort and narrow down data based on multiple criteria, which is especially useful in high-volume operational environments. Additionally, the system would benefit from the integration of other hospital modules that are not yet developed, such as Outpatient (Rawat Jalan), Mortuary (Kamar Mayat), and Emergency Department (IGD). Integrating these modules will create a more unified and comprehensive Hospital Information System, improving inter-departmental coordination and patient care continuity.

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