Development of Electronic Health Record System Functionality through the Creation of a Central Surgery Module

Dary Rahman[1], Teddie Darmizal[2], Muhammad Affandes[3], Pizaini[4]

[1,2,3,4] Department of Informatics Engineering, Faculty of Science and Technology, UIN Sultan Syarif Kasim Riau, Indonesia

*Corresponding Author: *Teddie Darmizal*

ABSTRACT: With the advancement of health technology, the use of Electronic Health Records (EHR) systems has become crucial in improving the efficiency and quality of services in various hospital units. However, the adoption of EHR systems is still uneven, especially in developing countries, including Indonesia. At the Pekanbaru Military Hospital, several departments have successfully implemented EHR systems, but the surgical department still uses a paper-based system for medical record keeping. Challenges faced include a lack of infrastructure and technical support. Therefore, the development of a central surgery module within the EHR system at Pekanbaru Military Hospital is necessary to enhance the efficiency and accuracy of medical record-keeping. This study aims to enhance the functionality of the EHR system in managing medical records in the surgical department by developing a central surgery module at the Pekanbaru Military Hospital. The software development methodology used in this study is the Agile model, which includes user requirements analysis, data collection, system implementation, as well as evaluation and validation. The Central Surgery Module that has been developed includes various features such as patient registration for surgery, recording of pre-operative, intra-operative, and post-operative patient data, surgical reports, and integration with laboratory and radiology systems. Through testing conducted using the black box testing technique, the results showed that 93.48% of the system functionality worked well, and using the User Acceptance Testing technique, it was found that 92.5% of the system functionality was acceptable to users.

KEYWORDS: Electronic Health Records, Central Surgery Module, Medical Record Management, Surgery

I. INTRODUCTION

With the advancement of health technology, the use of EHR systems has become crucial in improving the efficiency and quality of services in various hospital units (Li et al., 2022). However, in reality, the adoption of EHR systems remains uneven across hospitals, especially in hospitals in developing countries. This issue arises due to numerous factors that need to be considered before implementing an EHR system in a hospital.

The growth in the use of EHR systems worldwide has been quite rapid since several decades ago, especially when governments in several developed countries began encouraging healthcare facilities to adopt EHR systems (Gianfrancesco & Goldstein, 2021). The history of EHR system development began in 1992 when computer availability became more affordable and internet access began to speed up. Medical records, previously paper-based, slowly transitioned to EHR systems, marking the rapid growth of EHR system development since then. Over the past few decades, EHR systems have continued to evolve with improved functionalities and the growth of Health Information Exchange (HIE). International standards such as Health Level Seven (HL7) were developed to facilitate interoperability among various EHR systems. This development has also involved significant investments from both private and government sectors to enhance the capabilities and functionalities of EHR systems (Evans, 2016)

Several studies conducted in developing countries indicate that the adoption of EHR systems still lags behind. A study conducted in Kenya, Ghana, Nigeria, South Africa, and Saudi Arabia suggests that the adoption of EHR systems faces challenges such as inadequate technical support, poor infrastructure, and a lack of regulations governing EHR adoption (Woldemariam & Jimma, 2023). According to research by (Jung et al., 2020), the implementation of EHR systems is not an easy task, even for a country transitioning from a developing to a developed nation.

In contrast, Taiwan has experienced significant growth in the use of EHR systems since the enactment of the Healthcare Information Technology for Economic and Clinical Health Act in 2009. Out of 496 hospitals, approximately 411 hospitals and about 5,244 out of 9,782 private clinics have been certified to have interoperable EHR systems (Wang et al., 2022).

In Indonesia, despite uneven implementation of EHR systems, its development continues to progress alongside advancements in information technology. However, there are several challenges that need to be addressed in the implementation of EHR systems in Indonesia, such as technical standards, information security issues, and interoperability problems between EHR systems (Tilaar & Sewu, 2023). The Indonesian Ministry of Health has mandated that every healthcare facility must have an EHR system, but standardization for EHR system formats has not been officially established, and regulations regarding the mandatory ownership of EHR systems lack detailed explanation. This situation makes it impractical to integrate medical records across healthcare facilities, leading each facility to develop their own EHR systems based on their respective goals and needs (Emanuel, 2019).

One concrete example of these medical record-keeping issues is found in the surgical department of the Pekanbaru Military Hospital, which still uses a paper-based system for medical records. Challenges in implementing EHR systems at Pekanbaru Military Hospital include infrastructure deficiencies and lack of technical support. Despite these challenges, several other departments at Pekanbaru Military Hospital have successfully implemented EHR systems, indicating the potential for a comprehensive transition to digital systems.

II. METHODOLOGY

In software development, researchers utilize the Agile model, one of the System Development Life Cycle (SDLC) methods. The Agile model offers a flexible and adaptive workflow with incremental and iterative processes because it divides the entire software into smaller parts (Schramm et al., 2023). The process flow of the Agile model includes data collection, analysis, design, coding, testing, and review (Sharma et al., 2012). The research design employed by the researchers combines the research design approach used by (Jilcha Sileyew, 2020) with the workflow of the Agile model.
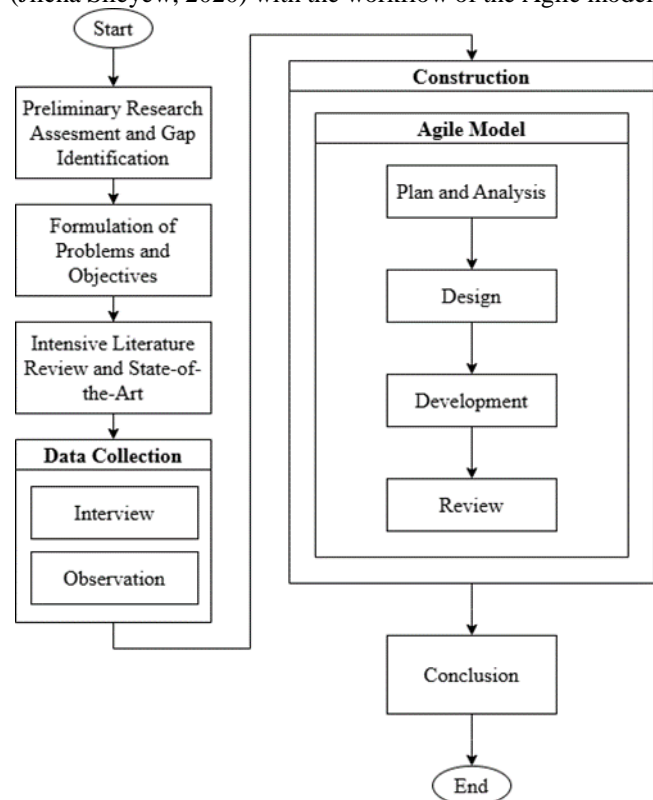
Figure 1. Research Design

A. Preliminary Research Assessment and Gap Identification

An initial assessment was conducted by identifying existing gaps in the Central Surgery Module that will be developed. This assessment aims to determine whether the Central Surgery Module is needed for the surgical services at Pekanbaru Military Hospital. The results of this assessment indicate that the surgical services at Pekanbaru Military Hospital require an EHR system.

B. Formulation Problems and Objectives

The assessment results indicate that medical record-keeping in the surgical services at Pekanbaru Military

Hospital is still paper-based, leading to various common issues associated with paper usage such as lost records, recording errors, and difficult access. An EHR system is needed to facilitate access and medical record-keeping, as well as to ensure patient data security.

C. Intensive Literature Review and State-of-the-Art

Surgery is one of the healthcare services provided at Pekanbaru Military Hospital, offering a wide range of surgical procedures across various specialties. These services include elective surgeries for non-emergency situations, as well as urgent surgeries for emergency cases. Specific workflows and procedures have been established for each type of surgical situation, whether elective or urgent (emergency). These workflows and procedures are designed with the primary goal of providing timely and appropriate care to every patient, ensuring that the medical interventions performed yield the best outcomes based on their medical conditions.
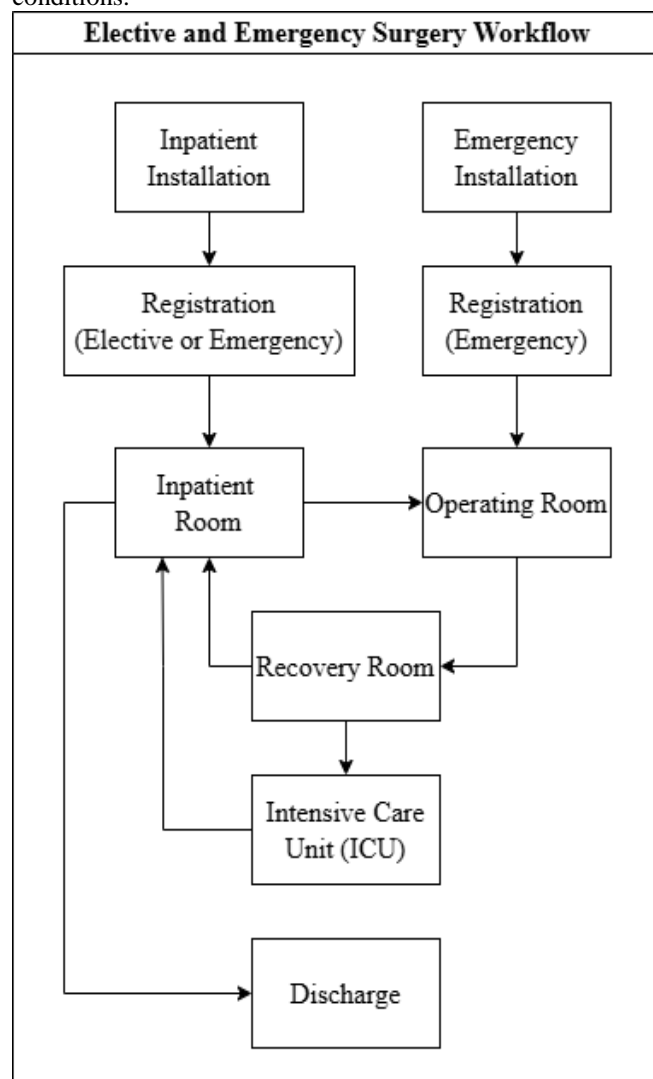
Figure 2. Elective and Emergency Surgery Workflow

In the central surgery process, there are two main interconnected components: surgery and anesthesia. Both components are performed simultaneously by doctors and nurses specialized in surgery or anesthesia. In the service process, surgical procedures are carried out by a team typically consisting of the operating surgeon, the attending physician responsible for the patient, the anesthesiologist,

surgical assistants, anesthesia nurses, circulating nurses, and instrument nurses. Each role has different tasks and responsibilities, and the number of each role in a surgical team depends on the complexity of the operation being performed.
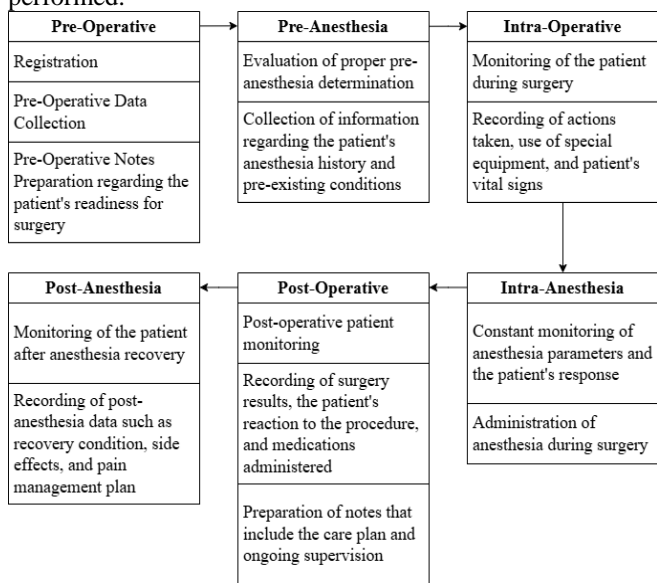
Pre-Operative	Pre-Anesthesia	Intra-Operative
Registration	Evaluation of proper pre-anesthesia determination	Monitoring of the patient during surgery
Pre-Operative Data Collection	Collection of information regarding the patient's anesthesia history and pre-existing conditions	Recording of actions taken, use of special equipment, and patient's vital signs
Pre-Operative Notes Preparation regarding the patient's readiness for surgery		

Post-Anesthesia	Post-Operative	Intra-Anesthesia
Monitoring of the patient after anesthesia recovery	Post-operative patient monitoring	Constant monitoring of anesthesia parameters and the patient's response
Recording of post-anesthesia data such as recovery condition, side effects, and pain management plan	Recording of surgery results, the patient's reaction to the procedure, and medications administered	Administration of anesthesia during surgery
	Preparation of notes that include the care plan and ongoing supervision	

Figure 3. Central Surgery Business Process

Surgery is a specialization involving manual and instrumental techniques applied to patients to investigate or treat pathological conditions such as diseases or injuries, aiming to improve bodily function or appearance (Sohal & Shubi, 2015). Anesthesia, on the other hand, is a medical intervention aimed at preventing patients from feeling pain during surgical procedures (Messina et al., 2016). According to the central surgery business process at Pekanbaru Military Hospital, surgical and anesthesia services are divided into three phases: pre-operative, intra-operative, and post-operative. The pre-operative phase involves processes conducted before surgery begins, typically including preparations by the surgical and anesthesia teams such as patient evaluation, laboratory tests, and various other pre-operative examinations. The intra-operative phase encompasses the surgical procedure itself taking place in the operating room. The post-operative phase involves monitoring the patient's condition after surgery, as not all patients recover immediately, requiring monitoring until they are stable and free from post-operative complications.

To enhance the efficiency and accuracy of medical record-keeping, the Central Surgery Module implements the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) and the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM). ICD-9-CM has been a mandatory standard for clinical billing purposes, particularly in the United States, since the late 1970s (Topaz et al., 2013). Meanwhile, ICD-10 has been used in the United States since 1999, adapted to meet coding needs for morbidity purposes (Outland et al., 2015). Implementing these classification codes is beneficial for improving healthcare service quality, enhancing patient health data tracking (Rahmathulla et al., 2014), and facilitating medical billing calculations (Hreha et al., 2020).

Based on research conducted among healthcare professionals in Ethiopia, 66% of respondents prefer using EHR systems over paper-based medical records. Among these respondents, 51% stated that EHR systems save more time, 33.7% mentioned that EHR systems can store more data, 30.6% highlighted that EHR systems make data access easier, 22.1% reported that EHR systems simplify report generation, and 30.3% indicated that EHR systems can improve service quality (Oumer et al., 2021)

From previous research conducted by (Seu et al., 2020), it was found that among plastic surgeons using EHR systems, they reported that the EHR system has a positive impact on the quality of patient care. This positive impact is also supported by staff responsible for the data entry process.

Furthermore, in their study, (Liu & Edye, 2020) concluded that after implementing EHR systems, there was an improvement in the quality of medical record documentation. Moreover, following the implementation of EHR systems, there was a reduction in post-operative hospital stay from previously 1 day 22 hours 34 minutes to 1 day 8 hours 53 minutes. This research aligns with earlier findings by (Yang et al., 2014), which stated that EHR implementation led to a decrease in average hospital stay for surgical patients by 2 days 7 hours to 2 days 19 hours 12 minutes.

Another foundation for designing the Central Surgery Module is the standardized accreditation data model regulated by the Hospital Accreditation Commission (KARS). This standard is known as the National Hospital Accreditation Standard (SNARS). According to the Director General of Medical Services Decree number YM.02.03.3.5.2626 regarding KARS and Other Health Facilities, KARS has the main task of assisting the Director General of Medical Services in planning, implementing, and evaluating hospital and other health facility accreditations. These tasks include developing standards, guidelines, and accreditation instruments aimed at improving the quality of healthcare services and patient safety in all hospitals across Indonesia.

Based on an intensive literature review and state-of-the-art analysis, it can be concluded that EHR systems in surgical services have a positive impact on the quality of patient care and the quality of medical record documentation. Referring to SNARS established by KARS, various requirements and guidelines have been set for hospitals to meet in order to enhance service quality and patient safety. Therefore, the design of the Central Surgery Module is not only based on research findings demonstrating the benefits of EHR but also aligns with the national standards set by KARS.
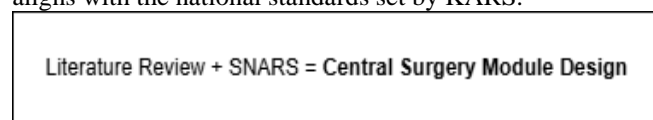
Literature Review + SNARS = Central Surgery Module Design

Figure 4. Central Surgery Module Design

Based on the (*Standar Nasional Akreditasi Rumah Sakit*, 2017), which can be applied to surgical services, particularly in medical services, specifically in the Anesthesia and Surgery Services (Pelayanan Anestesi dan Bedah, PAB) chapter, the implementation of SNARS in the Central Surgery Module covers aspects that must be fulfilled by the surgical installation in its service processes.

D. Data Collection
The following are the data collection methods used by the researchers.

1. Interview

   Interviews were conducted with the head of the surgical department, surgeons, and surgical nurses at Pekanbaru Military Hospital. The interviews aimed to gather information related to the workflow of surgical services at Pekanbaru Military Hospital. Additionally, the information collected by the researchers also covered the responsibilities of surgical medical staff, roles of medical personnel in the surgical process, and other relevant information.

2. Observation

   Observations were made on the EHR system currently in use at Pekanbaru Military Hospital. The purpose of these observations was to ensure that the developed system could integrate with the existing EHR system and align with the business processes of the surgical services at Pekanbaru Military Hospital.

III. RESULT

In developing the Central Surgery EHR system, researchers have employed the Agile model as the software development method. This choice was made due to its flexibility and ability to adapt to changing requirements throughout the system development process. The stages of system design based on the Agile model involve iterative cycles that allow for gradual adjustments and refinements to the system.

A. Design

The design is based on previous analysis conducted by creating Unified Modeling Language (UML) diagrams such as use case diagrams and class diagrams. These diagrams are designed to facilitate researchers in implementing the system analysis results into the program code.
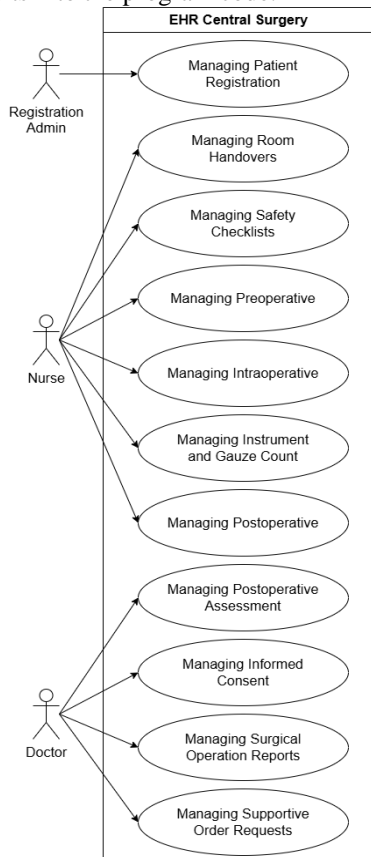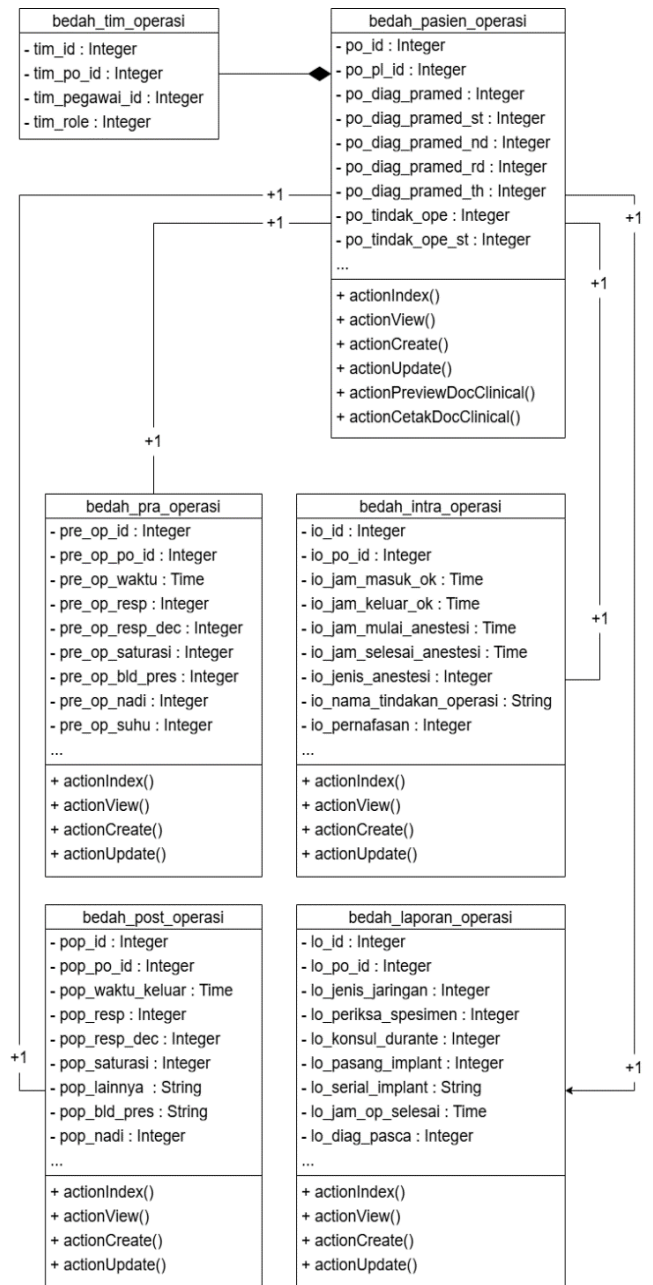

Figure 5. Use Case Diagram

Figure 6. Class Diagram

B. Implementation

The UML design created based on earlier analysis will be implemented, starting with the database construction process and continuing with coding. Below is a view of the system that has been developed.
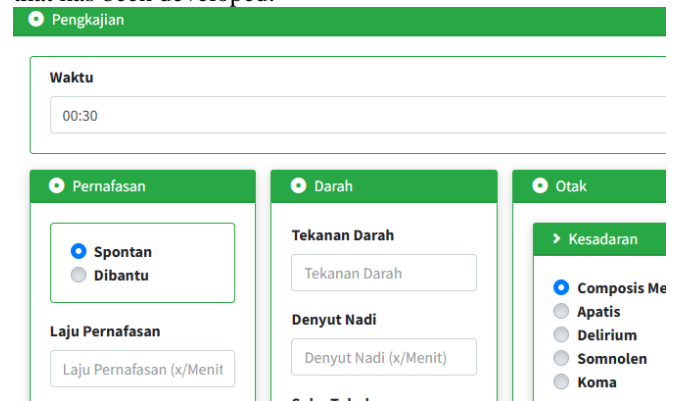

Figure 7. Pre-Operative Form

Preoperative form is designed to evaluate and prepare patients before undergoing surgery. It consists of assessing the patient's preoperative condition, preoperative issues, preoperative action plan, and preoperative nursing care.

Figure 8. Intra-Operative Form

The intra-operative form encompasses evaluating the patient's condition during the surgery process. The structure of the intra-operative form is not significantly different from the structure of the pre-operative form.

Figure 9. Post-Operative Form

The post-operative form covers assessing the patient's condition after undergoing the surgery process. This form shares a structure similar to the pre-operative and intra-operative forms, comprising assessment of the patient's condition, identifying issues, and outlining nursing care actions for the patient.

C. Testing

The system undergoes testing using Black Box and User Acceptance Test (UAT) methods.

1. Black Box

   Black Box testing is conducted on the system with 46 tests.

Table 1. List of Black Box Test

No.	Features	Test Case	Expected results	Status
1	Patient Registration	Entering the name of a new patient	Patient successfully added	Pass
2	Room Handover	Change room handover data	Error message appears	Pass
3	Safety Checklist	Ensure that the saved	Safety checklist data	Pass

		checklist data can be accessed	can be accessed and verified	
4	Pre-operative	Filling in pre-operative data	Pre-operative data saved successfully	Pass
5	Intra-operative	Changing intra-operative data	Intra-operative data updated successfully	Pass
6	Use of Gauze	Ensure that stored screen user data can be accessed	Screen usage data can be accessed and verified	Pass
7	Post-operative	Fill in post-operative data	Post-operative data is saved successfully	Pass
8	Informed Consent	Change informed consent data	Informed consent data updated successfully	Pass
9	Operation Report	Ensure that the operation report data that has been saved can be accessed	Operation report data can be accessed and verified	Pass
10	Operation Location	Fill in operation location data	Operation location data saved successfully	Pass
12	Blood Transfusion	Change blood transfusion data	Blood transfusion data updated successfully	Pass
...	...	...	...	...

From these tests, the black box testing resulted in a success rate of 93.48%.

2. User Acceptance Test (UAT)

   UAT was conducted on the Central Surgery EHR system by a surgeon with 16 tests, a surgical nurse with 24 tests, and an administrator with 32 tests.

Table 2. List of UAT Testing Name

No.	Testing Name
1	Login testing
2	Test for registering surgery patients
3	Testing to see the patient's medical examination history
4	Testing changing room handover data
5	Testing accessing and creating safety checklist data
6	Testing accessing and creating pre-operative data
7	Testing changing intra-operative data
8	Testing accessing and creating gauze usage data
9	Testing changing post-operative data

10	Testing accessing and creating inform consent data
11	Testing accessing and creating operation report data
12	Testing changing operation location data
13	Testing accessing and creating blood transfusion data
...	...

Table 3. UAT Results

No.	Assessment	Number of Admin Test Cases	Number of Doctor Test Cases	Number of Nurse Test Cases	Total Value
1	Very Good	20	10	15	225
2	Good	12	6	9	108
3	Neutral	0	0	0	0
4	Less	0	0	0	0
5	Very Less	0	0	0	0
	Total	32	16	24	333

Based on the results of the User Acceptance Test conducted, it can be concluded that the Central Surgery EHR system performed well with a success rate of 92.5%.

IV. DISCUSSION

The development of the Electronic Health Record (EHR) system for the Central Surgery module at Pekanbaru Army Hospital marks a significant advancement in surgical record management at Pekanbaru Military Hospital. While the module has successfully integrated various comprehensive functions such as patient registration and detailed procedural documentation, its practical implementation has revealed several challenges, particularly during the intraoperative phase. Healthcare professionals, including doc-tors and nurses, have reported difficulties in filling out intraoperative forms, which can affect the efficiency and accuracy of data entry during critical surgical procedures.

To address these challenges, Artificial Intelligence (AI) integration emerges as a viable solution. AI-powered systems can automate data entry by recognizing and pro-cessing voice commands, allowing surgeons and nurses to input data without using their hands while focusing on patient care. By leveraging Natural Language Processing (NLP) and machine learning, the system can learn from previous records and improve its accuracy over time, ensuring that the documentation process becomes more intuitive and less prone to human error. The implementation of AI can enhance system usability and facilitate smoother adoption processes among medical staff, ultimately leading to im-proved patient safety and operational efficiency.

The implications of this research underscore that healthcare information technology development should be viewed as a long-term investment requiring sustained sup-port and commitment from various stakeholders, including hospital management, medical staff, and IT departments. Additionally, an ergonomic approach to system design and effective training for end-users are crucial to enhancing adoption and utilization of the developed system.

Overall, the development of the EHR System for the Central Surgery module at Pekanbaru Army Hospital offers a valuable contribution to improving medical record management and healthcare service quality. However, additional steps are needed to ensure the sustainability and effectiveness of this system in the long term.

V. CONCLUSION

The development of the Central Surgery Module has significantly improved the efficiency and accuracy of medical record-keeping in the surgical services at Pekanbaru Military Hospital. The module includes comprehensive functionalities such as patient registration, pre-operative, intra-operative, and post-operative data recording, as well as operation reports. Additionally, it integrates seamlessly with laboratory and radiology systems, facilitating effective data exchange and interoperability. The system was subjected to rigorous testing using black box testing techniques, achieving a functionality score of 93.48%. User Acceptance Testing (UAT) indicated a high level of user satisfaction, with an acceptance rate of 92.5%, demonstrating that the module effectively meets the needs of healthcare professionals in the surgical services.

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