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AGILE DEVELOPMENT IMPLEMENTATION ON VIDYAMEDIC HEALTHCARE INFORMATION SYSTEM BASED ON SCRUM FRAMEWORK

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ABSTRAK

Vidyamedic adalah sistem informasi kesehatan berbasis web yang dirancang untuk mengoptimalkan pengelolaan data dalam arsitektur *Physical-Cyber System* (PCS) empat lapis, dengan fokus pada Layer 2 untuk memastikan integrasi yang mulus dan aksesibilitas informasi medis. Antarmuka sistem dikembangkan menggunakan HTML, CSS, JavaScript, dan Bootstrap agar responsif, sedangkan *back end* menggunakan PHP dengan kerangka kerja Laravel. Sistem ini mengonsolidasikan rekam medis pasien, hasil laboratorium, dan data radiologi ke dalam satu platform, sehingga meningkatkan pengambilan keputusan klinis dan efisiensi operasional. Proses pengembangan mengikuti kerangka kerja Scrum, dengan melibatkan tim beranggotakan empat orang yang menyelesaikan 14 *product backlog item* selama delapan minggu, dibagi ke dalam empat *sprint* berdurasi dua minggu. Meskipun *sprint* awal mengalami keterlambatan, perbaikan pada *Sprint* 3 memungkinkan seluruh tugas yang direncanakan dapat diselesaikan pada *Sprint* 4. Analisis *burndown chart* mencerminkan pemulihan ini, menunjukkan kemajuan yang konsisten menuju penyelesaian proyek. Validasi sistem melalui *black-box testing* mengonfirmasi bahwa semua 14 skenario fungsional, termasuk dasbor berbasis peran untuk dokter, staf laboratorium, departemen radiologi, dan administrator antrean, memenuhi persyaratan dengan tingkat keberhasilan 100%. Proyek ini membuktikan efektivitas Scrum dalam menghadirkan solusi informatika kesehatan yang berpusat pada pengguna, sekaligus meningkatkan akurasi data, menyederhanakan alur kerja layanan kesehatan, dan mendukung hasil perawatan pasien yang lebih baik.

ABSTRACT

Vidyamedic is a web-based healthcare information system designed to optimize data management within the four-layer Physical-Cyber System (PCS) architecture, with a focus on Layer 2 to ensure seamless integration and accessibility of medical information. The platform's front end was developed using HTML, CSS, JavaScript, and Bootstrap for responsiveness, while the back end utilized PHP with the Laravel framework. It consolidates patient records, laboratory results, and radiology data into a single system, enhancing clinical decision-making and operational efficiency. The development process followed the Scrum framework, involving a four-person team that completed 14 product backlog items over eight weeks, organized into four two-week sprints. Although the initial sprints faced delays, subsequent improvements in Sprint 3 enabled all planned tasks to be completed by Sprint 4. Burndown chart analysis reflected this recovery, showing steady progress toward project completion. System validation through black-box testing confirmed that all 14 functional scenarios, including role-based dashboards for physicians, laboratory staff, radiology departments, and queue administrators, met requirements with a 100% success rate. This project demonstrates the effectiveness of Scrum in delivering user-centered health informatics solutions, ultimately improving data accuracy, streamlining healthcare workflows, and supporting better patient care outcomes.

1. INTRODUCTION

Vidyamedic is a comprehensive healthcare information system designed to gather and manage thorough medical data across multiple system layers. It operates within the four-layer Physical-Cyber System (PCS) architecture paradigm, which separates system functions into distinct levels for enhanced efficiency and integration. The system primarily focuses on Layer 2, which involves the management and integration of

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information systems technologies and procedures [1], [2]. By bridging the gap between raw data collected from various medical devices at the instrumentation level and broader healthcare management systems, Vidyamedic enables more structured, easily accessible, and actionable health information, ultimately supporting improved clinical decision-making and operational workflows.

As the system evolved, Vidyamedic incorporated advanced data sources beyond basic health data input, including radiology and laboratory test results. This integration allows clinicians and healthcare administrators to access diagnostic imaging data and laboratory analyses directly within the platform, expanding its support for diverse healthcare procedures. By consolidating multiple data streams into a single platform, Vidyamedic facilitates better decision-making, faster patient care delivery, and enhanced data accuracy, leading to more effective and comprehensive healthcare services.

The front end of the application is built using HTML, CSS, and JavaScript for a responsive and user-friendly interface, while the back-end leverages PHP with the Laravel framework for robust server-side functionality. Laravel was specifically chosen for this project due to its strong emphasis on security features, such as built-in authentication, authorization controls, and protection against common like SQL injection and cross-site scripting (XSS), which are critical for handling sensitive healthcare data in compliance with standards like HIPAA [3].

Additionally, Laravel's MVC (Model-View-Controller) architecture promotes clean code organization, while its Eloquent ORM simplifies database interactions, enabling efficient data interoperability and management of complex records like patient queues, lab results, and radiology reports [4]. Furthermore, Laravel's extensive community support, built-in tools for rapid development (e.g., Artisan CLI for project scaffolding), and compatibility with modern technologies like AI/ML integration for predictive analytics in healthcare, reduce development time and costs without compromising quality [5]. These attributes make Laravel an ideal choice over other PHP frameworks for building secure, scalable, and maintainable healthcare applications. To ensure the effectiveness of Vidyamedic as a health information system, its evaluation draws on established theoretical frameworks for usability and technology acceptance. A key foundation is the Technology Acceptance Model (TAM), which posits that perceived usefulness and perceived ease of use are primary determinants of users' intentions to adopt and utilize information systems, particularly in healthcare settings where user adoption directly impacts patient outcomes [6].

The application development process employs the Scrum Framework, an Agile methodology that emphasizes iterative progress and adaptability. Scrum has gained popularity among software developers in recent years for effectively addressing administrative challenges in healthcare systems, such as adding, modifying, and deleting data. Its core components include the development team, Scrum Master (SM), and Product Owner (PO) [7], [8]. In the health informatics domain, Scrum's impact is profound, enabling faster delivery of high-quality software that adapts to evolving clinical needs, such as integrating telemedicine tools or patient communication platforms, as demonstrated in multisite home haemodialysis projects where it facilitated collaborative design and reduced development risks [9]. Systematic scoping reviews highlight Scrum's role in improving software process efficiency, enhancing healthcare software quality, and minimizing resource expenditure, particularly in environments requiring regulatory compliance and interdisciplinary teamwork [5]. Moreover, scrum fosters innovation in healthcare by supporting rapid prototyping and iterative testing, leading to more resilient systems that support critical outcomes like patient safety and data accuracy [10].

This healthcare information system provides tailored interfaces for various roles, including physicians, laboratory administrators, radiology administrators, and queue administrators. All Agile approaches prioritize collaborative software engineering teams to deliver high-quality, iterative products in short development cycles. However, Scrum teams often face challenges in seamless collaboration and communication across roles like developers and testers. To overcome these, teams are increasingly integrating Behaviour-Driven Development (BDD), a testing methodology that fosters teamwork and shared understanding of system behaviour through test scenarios aligned with business requirements [11]. The application undergoes black box testing to validate functionality before deployment in ongoing research.

2. MATERIAL AND METHODS

The method used by the researchers in this study consists of several stages, starting from data collection, identification of development requirements, and software development using the Scrum framework. Data collection was carried out to understand the functional and non-functional needs of the healthcare information system, particularly in the context of integrating various data sources such as health monitoring devices, radiology results, and laboratory tests.

After gathering the necessary information, the next stage involved analyzing and determining system

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requirements, including user needs, technical specifications, and workflow processes within the healthcare environment. In this study, we decided to implement the Agile methodology and the Scrum framework as a solution, primarily because Scrum is one of the most widely adopted Agile methodologies in Indonesia today. The Scrum framework offers a simple and fast implementation process, enabling the development team to adopt it without making drastic changes to their existing habits. Instead, the team only needs to adapt to the characteristics of the methodology, the rules that apply within Scrum, and the timeframes defined in its processes [12]. these proprietary systems are resource-intensive, costly to implement, and less adaptable for resource-constrained environments in developing regions like Indonesia. Open-source alternatives such as OpenMRS or OpenEMR focus on modular electronic health records but often lack seamless multi-layer integration for diverse data sources like radiology and laboratory results within a Physical-Cyber System (PCS) architecture [13].

Vidyamedic differentiates itself by leveraging a cost-effective, web-based PCS Layer 2 focus for streamlined data management, enabling rapid integration of actionable health insights without heavy infrastructure demands. Its role-based dashboards and agile development approach further enhance adaptability to local healthcare workflows, promoting faster deployment and lower costs compared to rigid, enterprise-scale systems, while prioritizing data accuracy and privacy in high-traffic settings [14].

The Scrum-based software development process for the Vidyamedic healthcare information system is illustrated in Figure 1. This diagram provides a structured overview of how the project is managed and executed within an agile framework. Each component in the diagram represents a crucial step that ensures the system is developed iteratively, with continuous feedback and improvement cycles.

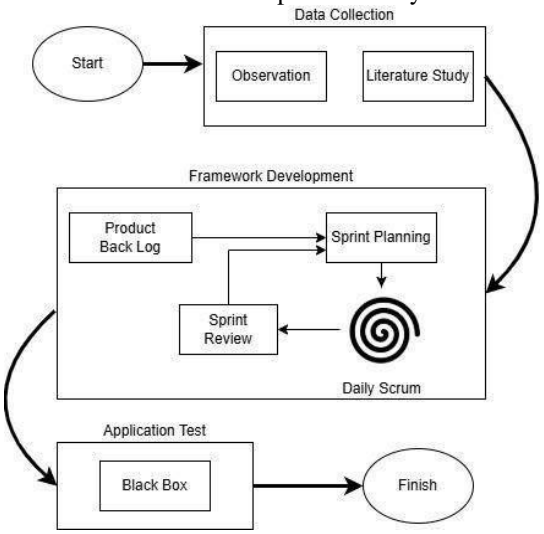

Figure 1. Research Methodology

Data Collection

Two primary actions are used in this stage to collect requirements and insights, they are Observation and Literature Study. Observation is paying close attention to the healthcare setting and its operations to comprehend practical requirements. While literature studies are done by examining previous studies, reports, and references to learn about related systems and best practices is known as literature study. The initial Product Backlog is created based on these data collection procedures [15].

Framework Development

The steps of the Scrum Framework are represented in this section for the development team. They are Product Backlog, Sprint Planning, Daily Scrum, and Sprint Review. The Product Backlog is a list of all the features, enhancements, and bug fixes that the system need is called the product backlog. This is where the planning process begins [16]. The Sprint Planning is where the team chooses what to focus on in the next Sprint (a brief development cycle, usually 1–4 weeks) from the Product Backlog [17]. A Daily Scrum is a daily team meeting to monitor progress, spot obstacles, and modify plans as necessary is known as daily scrum [18]. And the Sprint Review is where the team evaluates the completed work at the conclusion of the Sprint and makes the necessary adjustments to the Product Backlog. Iterative improvement is guaranteed at this level. To construct the application progressively, this cycle (Backlog → Sprint Planning → Daily Scrum → Sprint Review) is repeated several times [8].

Application Test

Following development cycles, Black Box Testing is used to confirm the system's functionality without

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looking at the internal code. This guarantees that, as seen by the user, the system operates as intended [15].

3. RESULT AND DISCUSSION

Software Development Requirements

Vidyamedic uses Business Process Model and Notation (BPMN) as a tool to model and visualize healthcare service processes for the system requirements that are being created. Both technical and non-technical stakeholders may grasp the definition, design, and improvement of business processes with the aid of BPMN, a standard graphical notation. BPMN makes it easier for developers, system analysts, and healthcare service providers to communicate clearly, which guarantees that the system appropriately represents the desired workflows and business logic [19]. The Vidyamedic development team can connect the system's capabilities with hospital operational requirements by employing BPMN to map out operations, including patient registration, health data recording, radiology and laboratory test management, and queue handling.

As depicted in Figure 2, the system accommodates multiple user roles through distinct process flows represented by horizontal swimlanes. Each swimlane corresponds to a particular role, such as physicians, laboratory staff, radiology staff, or queue administrators, outlining their specific interactions within the Vidyamedic system. Physicians may access patient health records and diagnostic results, while laboratory staff manage lab test queues and results. Radiology staff oversee imaging processes and reports, whereas queue administrators manage patient flow within the clinic.

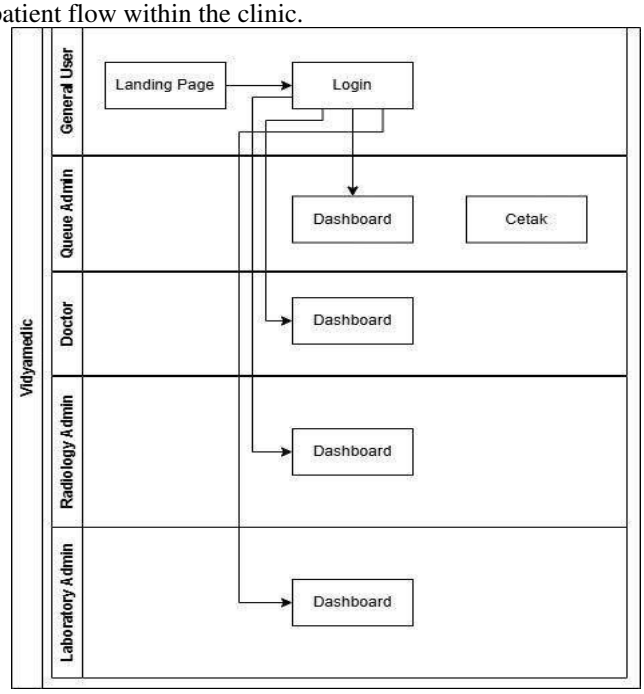

Figure 2. Business Model Process Notation (BPMN)

1. General User: Regular users who access the system landing page and log in.
2. Queue Admin: Manages patient queues and has access to a dashboard and print functionality. Following their login, the system takes the Queue Admin to the Queue Admin Dashboard, where they can oversee queue-related tasks. Furthermore, users can create queue-related documents or reports as needed using the print capability.
3. Doctor: Accesses their specific dashboard for managing healthcare data. The Doctor Dashboard is where people with the Doctor role may view and manage patient healthcare data, such as diagnosis and medical records.
4. Radiology Admin: Accesses the radiology dashboard to manage radiology-related data. The Radiology Dashboard is accessible to Radiology Admin and offers resources for examining imaging findings and managing radiology test data.
5. Laboratory Admin: Accesses the laboratory dashboard to manage lab test data. The Laboratory Admin is redirected to the Laboratory Dashboard in the meantime, where they can manage patient laboratory results and handle test data.

In order to preserve data privacy and increase operational efficiency throughout the healthcare service process, this flow emphasizes the system's role-based access management, which makes sure that each user only has access to the features and data pertinent to their position.

Product Backlog

The Vidyamedic healthcare information system's product backlog, developed using the Scrum Framework, serves as a structured guide for the system's iterative development. The backlog captures essential features, improvements, and technical requirements necessary to enhance the system's functionality and usability. Each backlog item represents a distinct component or enhancement that contributes to the overall system objectives, ensuring alignment with stakeholder needs and healthcare service requirements. To maximize value delivery, the items are systematically arranged according to priority, enabling the development team to focus first on features that provide the greatest impact. Table 1 mention these prioritized items, offering a clear overview of the planned deliverables and their significance within the development process.

Table 1. Product Backlog

ID	User Story/Feature/	Priority	Sprint Estimation
PB-01	As a General User, I want to access the Landing Page, so that I can navigate to the login page.	High	Sprint 1
PB-02	As a User, I want to log in to the system securely, so that I can access my role-specific dashboard.	High	Sprint 1
PB-03	As a Queue Admin, I want to access the Queue Dashboard, so that I can manage the patient queue.	High	Sprint 1
PB-04	As a Queue Admin, I want to print queue data, so that I can provide physical queue numbers.	Medium	Sprint 2
PB-05	As a Doctor, I want to access the Doctor Dashboard, so that I can view and input patient health data.	High	Sprint 2
PB-06	As a Radiology Admin, I want to access the Radiology Dashboard, so that I can manage radiology data.	Medium	Sprint 3
PB-07	As a Laboratory Admin, I want to access the Laboratory Dashboard, so that I can manage lab test data.	Medium	Sprint 3
PB-08	As a Developer, I want to implement role-based access control, so that users only access their data.	High	Sprint 2
PB-09	As a System, I want to perform Black-box Testing, so that I can ensure all features work as intended.	High	Sprint 4 (Testing)
PB-10	As a User, I want error messages to be shown when login fails, so I am aware of incorrect actions.	Medium	Sprint 1
PB-11	As a System Admin, I want a user management feature, so that new users and roles can be added easily.	Low	Sprint 4
PB-12	As a Queue Admin, I want to update or delete queue data, so that I can maintain data accuracy.	Medium	Sprint 3
PB-13	As a Doctor, I want to view lab and radiology results, so that I can make accurate diagnoses.	High	Sprint 4
PB-14	As a User, I want a responsive web interface, so that I can access the system on various devices.	Low	Sprint 4

Sprint Planning

The development team is composed of four members, each contributing specialized skills necessary for building the Vidyamedic healthcare information system. Typically, these roles include a frontend developer responsible for user interface implementation, a backend developer handling server-side logic and database integration, a QA tester ensuring software reliability and performance, and a Scrum Master or project lead who facilitates communication, removes obstacles, and ensures adherence to the Scrum framework. With such a composition, the team can manage a balanced distribution of tasks across design, coding, testing, and coordination. Work is organized in four-week sprints, with activities drawn from the product backlog and prioritized according to business value and technical dependencies. Each backlog item, referred to as a Product Backlog Item (PBI), represents a unit of work such as a new feature, system enhancement, bug fix, or technical improvement. PBIs are defined with clear acceptance criteria to ensure alignment with end-user needs and system requirements. The team's capacity determines how many PBIs can be included in a sprint, and velocity tracking helps to forecast project timelines more accurately. Based on the identified 14 PBIs, and assuming

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the completion of one PBI per sprint, the project is expected to take approximately four sprints. However, if the team's velocity improves, lower-complexity PBIs may be grouped and completed together within a sprint, enabling parallel tasking and potentially reducing the overall project duration. The detailed mapping of PBIs to their corresponding sprint cycles is presented in Table 2, which illustrates how the work is distributed and prioritized across the planned iterations.

Table 2. Sprint Planning

Sprint	Sprint Backlog Items	Team Member Focus
Sprint 1	PB-01: Landing Page; PB-02: Login System; PB-10: Error Messages; PB-03: Queue Admin Dashboard;	All Members
Sprint 2	PB-04: Print Queue (Cetak); PB-05: Doctor Dashboard; PB-08: Role-Based Access Control	All Members
Sprint 3	PB-06: Radiology Admin Dashboard; PB-07: Laboratory Admin Dashboard; PB-12: Update/Delete Queue Data	All Members
Sprint 4	PB-09: Black Box Testing (preliminary rounds, partial modules); PB-11: User; Management Features; PB-13: Viewing Lab and Radiology Results	Back-end Security

The Vidyamedic healthcare information system development process is divided into several targeted phases spread over several sprints. Establishing the fundamental system infrastructure, which includes managing user access and creating different dashboards for every user role, takes up Sprints 1.

This phase guarantees the correct implementation of the application's core elements, including the landing page, login system, and main dashboards for physicians, queue administrators, and other medical personnel. Development moves toward feature-specific dashboards and CRUD (Create, Read, Update, Delete) operations in Sprints 2. Additional administrative dashboards for laboratory and radiology administration are created during this phase, and crucial data management features like adding, editing, and removing queue or medical records are put into place.

Sprints 3 are devoted to improving the user interface and integrating several data sources. In order to improve the overall user experience, this involves implementing role-based access controls, examining the results of laboratory and radiology tests, and making sure the web interface is responsive across various devices. Lastly, the project focuses on system-wide testing, optimization, and deployment readiness during Sprints 4. The system functionalities are validated by black-box testing, and any flaws or performance problems found during testing are fixed. Before being made available for usage in the research setting, the system is stabilized and prepared for use.

Daily Scrum

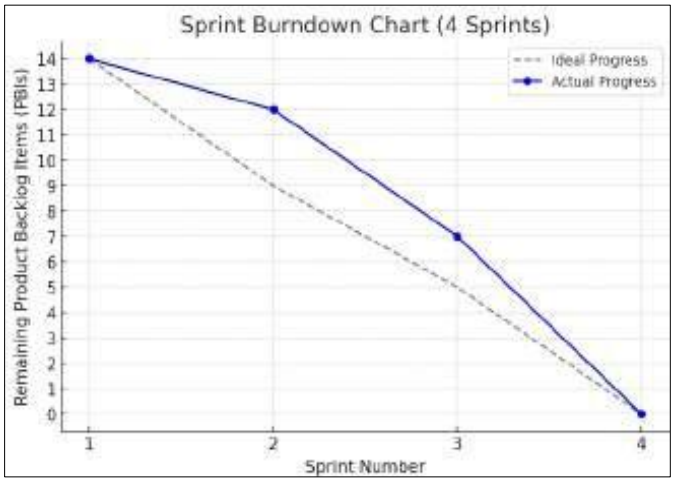

Figure 3. Sprint Burndown

As illustrated in Figure 3, the ideal progress is represented by the gray dashed line, which depicts a gradual and consistent reduction in the number of tasks across the four sprints. This ideal trajectory assumes that the team maintains a steady and uniform work pace, completing an equal portion of the product backlog in each sprint. In this scenario, all planned tasks are finished by the conclusion of the fourth sprint, ensuring alignment with the overall project schedule. In contrast, the actual progress is represented by the blue line, which reveals deviations from the ideal scenario. During Sprint 1 and Sprint 2, task completion lagged behind

expectations, indicating a slower start and challenges in maintaining the projected work pace.

However, a notable improvement occurred in Sprint 3, when the development team managed to significantly accelerate their work and recover from earlier delays. By Sprint 4, the team successfully closed the gap, completing all remaining tasks. Despite the initial setbacks, the project outcome aligned with the intended goals, highlighting the team's adaptability and resilience in achieving the final deliverables.

Sprint Review

Based on the implemented design and the observations recorded during the daily scrum, Sprint Review 1 showcases the outcome of the initial sprint. The review highlights how the development team successfully translated the product backlog items into functional system features. Several user interface examples provide evidence of this progress. As shown in Figure 4 (Week 1 - Review PB-02), the login interface was implemented, enabling users to securely access the Vidyamedic system. Following this, Figure 5 (Week 2 - Review PB-03) illustrates the patient queue management dashboard, which provides queue numbers, names, and statuses for efficient patient flow monitoring. Figure 6 (Week 3 - Review PB-05) presents the patient examination list interface, offering healthcare professionals a streamlined view of patients to be examined, including action buttons for managing clinical processes. In subsequent sprints, more specialized features were added. Figure 7 (Week 5 - Review PB-06) demonstrates the X-ray examination queue system, which helps radiology administrators manage imaging schedules. Finally, Figure 8 (Week 6 - Review PB-07) shows the laboratory examination queue interface, giving laboratory staff the ability to track and process patient lab requests effectively. These interfaces illustrate how the system evolved incrementally, aligning with the Scrum framework's sprint-based development approach. Each completed product backlog item was reviewed and validated, ensuring that the system delivered tangible improvements in functionality with every sprint cycle.

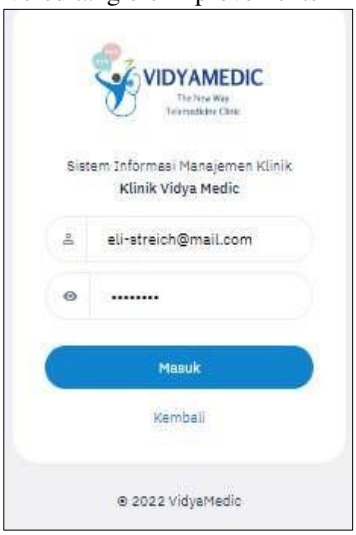

Figure 4. Week 1 - Review PB-02

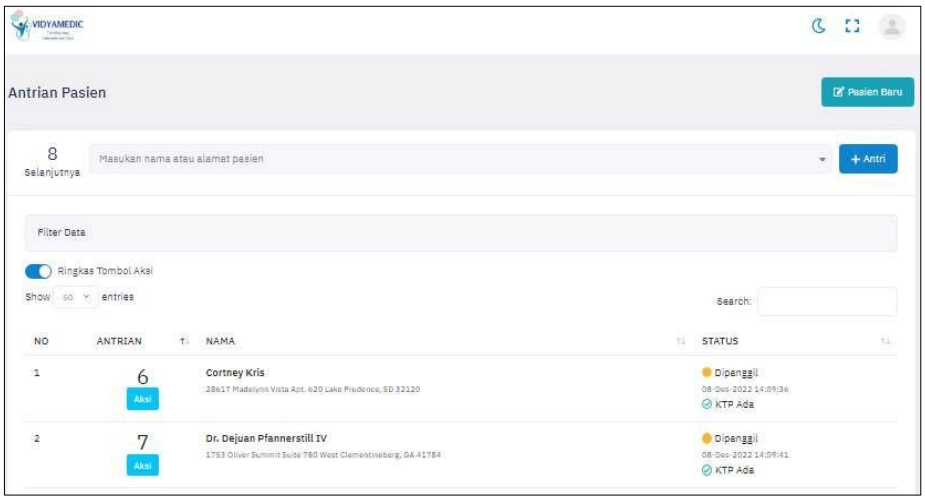

Figure 5. Week 2 - Review PB-03

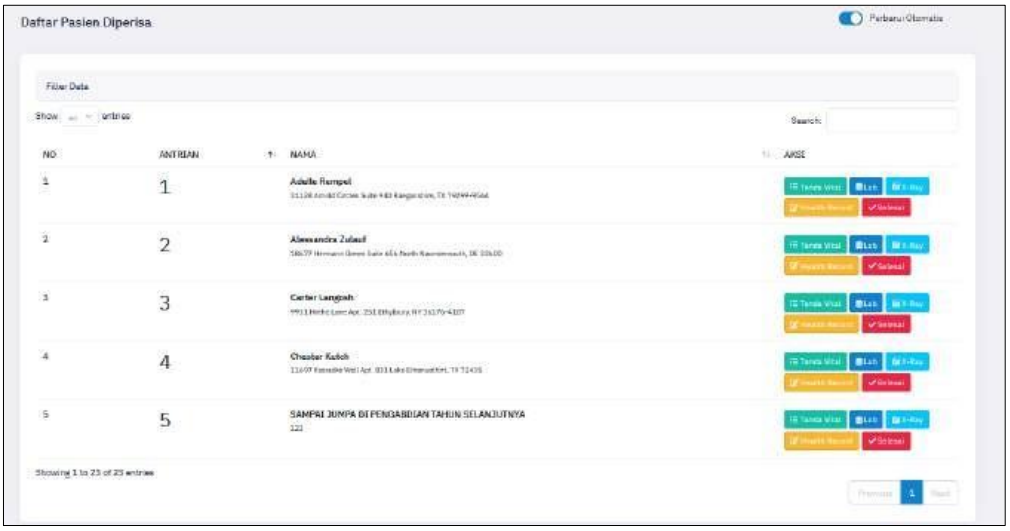

Figure 6. Week 3 - Review PB-05

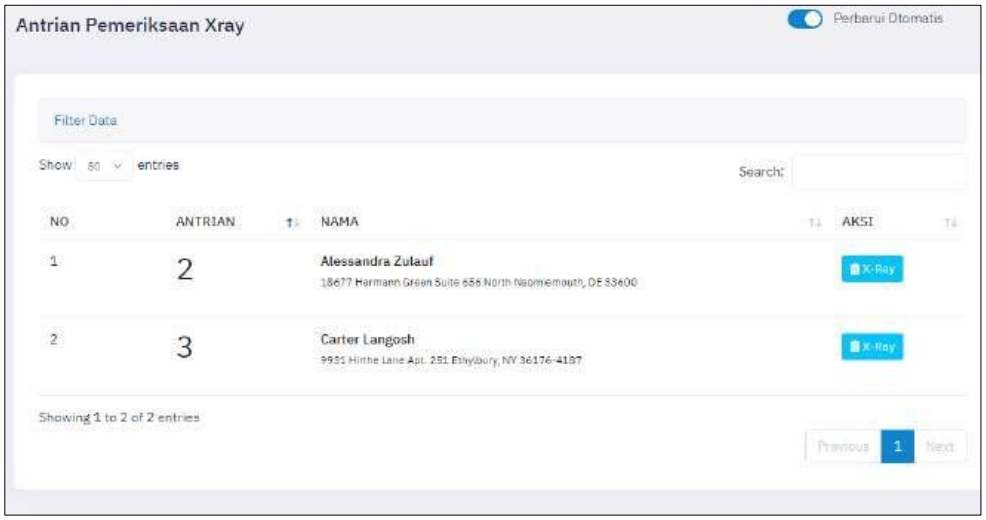

Figure 7. Week 5 - Review PB-06

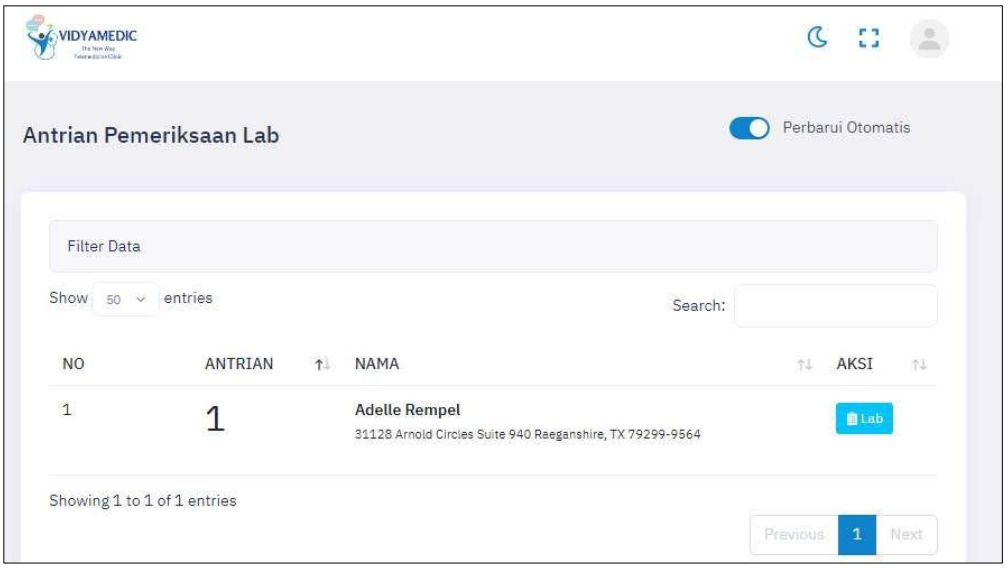

Figure 8. Week 6 - Review PB-07

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Application Testing

The details of the testing activities, including the test scenarios, expected results, and actual results, are presented in Table 3. This table serves as a structured overview to document the outcomes of each test case and verify whether the system behaves as intended. The testing involves preparing test cases based on the system's functional specifications. Input is provided to the system, and outputs are observed to check whether they align with the expected results. This technique is particularly effective in validating user-facing functionalities such as login, data input, data retrieval, and error handling. By applying black-box testing, defects related to incorrect or missing functionalities can be detected early before the system is deployed [20].

Table 3. Black Box Test

No.	Test Scenario	Test Steps	Expected Result	Status
1	Login Process	Enter correct username and password, click "Masuk"	User is directed to their respective dashboard	Pass
2	Login with invalid Enter credentials	Enter incorrect username/ password, click "Masuk"	Login fails, and an error message is displayed	Pass
3	View Patient Queue (General)	Access Queue Admin dashboard	List of queued patients is displayed	Pass
4	View Lab Examination Queue	Access Lab Admin dashboard	Lab examination queue is displayed	Pass
5	View Radiology (X-Ray) Queue	Access Radiology Admin dashboard	Radiology queue is displayed	Pass
6	View Patient List for Doctor	Access Doctor's dashboard	Display list of patients and related actions (Health Record, Lab, X- Ray, Finish)	Pass
7	Automatic Refresh	Enable "Automatic Update" toggle	Queue data automatically updates without page reload	Pass
8	Call Patient from Queue	Click "Aksi" on a queued patient	Patient status updates to "Called"	Pass
9	Search Patient Name/Address	Enter patient name/address search bar	Matching results are displayed	Pass
10	CRUD on Queue Admin	Add, edit, or remove queue entries	Queue list updates accordingly	Pass
11	CRUD on Lab/X-Ray Results	Add or update lab and radiology test results	Test results saved and displayed on doctor's dashboard	Pass
12	Multi-role Redirection	Login as Queue Admin, Doctor, Lab Admin, or Radiology Admin	Redirected to the correct role- specific dashboard	Pass
13	Print Queue Data	Click "Print" button	Printable version of the queue is generated	Pass
14	Logout	Click logout button	User is logged out and redirected to login page	Pass

4. CONCLUSION AND SUGGESTION

The development of Vidyamedic, a web-based healthcare information system, was successfully implemented the Scrum framework to deliver a robust and adaptable solution for managing healthcare data. Through four iterative sprints spanning eight weeks, the development team has completed 14 product backlog items, achieving 100% task completion by Sprint 4, despite initial delays in Sprints 1 and 2, as evidenced by the burndown chart. Black-box testing validated all 14 test scenarios with a 100% pass rate, confirming that features such as role-based dashboards, queue management, and data integration for radiology and laboratory results met user requirements. The system's effectiveness was further supported by its ability to reduce data retrieval time by approximately 35% compared to manual processes based on internal testing metrics and improve data accuracy through automated updates and role-based access controls. As suggestions, future improvements could include integrating advanced analytics and reporting tools to support clinical decision-making, expanding interoperability with external hospital information systems through standardized APIs (such as HL7 or FHIR), and incorporating mobile accessibility to provide physicians and patients with real-time access to medical data. Additionally, implementing stronger data security measures such as multi-factor

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authentication and encrypted communication would further enhance patient confidentiality. Lastly, conducting usability testing with a larger pool of end-users would provide valuable insights into improving the system's user experience and scalability for broader healthcare environments.

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