

Design and Implementation of Telemedicine Platform for Neurology Consultations an Agile Development Approach

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Article Info	ABSTRACT
<p>Keywords: Telemedicine, Agile Methodology, Neurology Consultations, Neurology Clinics.</p>	<p>This research aims to develop a telemedicine platform that can be used for neurology consultations efficiently and effectively. The development method used is Agile Development, which allows for the breaking down work into sprints that can be done iteratively. The research stages include user needs analysis, application development based on the telemedicine system architecture design, user acceptance evaluation, and final evaluation of the effectiveness of the telemedicine platform. The evaluation results showed that the platform improved the accessibility and quality of remote neurology consultation services by providing a satisfactory user experience. This research makes a significant contribution to developing a telemedicine platform for neurology consultations with a focus on user needs and the application of efficient development methodologies, which can be an effective solution in expanding the accessibility of neurology healthcare services and improving the quality of services provided by neurology doctors.</p>
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INTRODUCTION

Telemedicine has become one of the crucial innovations in the healthcare sector that enables remote medical services through information and communication technology. Telemedicine connects patients with healthcare providers without physical meetings that are often difficult to organize, especially for patients who live in remote areas or are hard to reach by conventional healthcare facilities. With telemedicine, patients can easily access medical consultations, receive diagnoses, and get treatment without traveling long distances or attending clinics in person (Cronin, 2023; Horita et al., 2023; Yip et al., 2023). This saves travel time and costs for patients and allows healthcare professionals to provide more efficient and effective services.

Neurology consultation is one of the healthcare fields that urgently needs the integration of telemedicine technology. Neurology is a branch of medicine that focuses on diagnosing and treating disorders of the nervous system, including the brain, spinal cord, peripheral nerves, and muscles. Patients with neurological disorders often require long-term care and routine monitoring that requires regular visits to neurology specialists. However, the limited number of neurology specialists, especially in rural or remote areas, often makes

access to neurological consultation and treatment challenging for many of the population (Demaerschalk et al., 2023; Hinault et al., 2023; Rangel et al., 2022).

The main challenges in implementing telemedicine for neurology consultation include several crucial aspects. One is fulfilling strict medical data security standards to protect sensitive patient information transmitted through telemedicine platforms. In the context of neurology, medical data may include confidential information about the patient's neurological condition, diagnostic test results such as brain imaging (MRI, CT scan), and treatment history that must be kept confidential. Therefore, telemedicine platforms for neurology consultations must meet high data security standards to prevent unauthorized access and information leakage.

In addition, integrating existing health information systems is an essential challenge in developing a telemedicine platform for neurology consultations (Ablat et al., 2022; Miller et al., 2023; Pevy et al., 2023; Shen et al., 2024; Waerzeggers et al., 2010). Many hospitals and clinics already have well-established health information systems to record patient medical histories, consultation schedules, and diagnostic test results. Developing a telemedicine platform that seamlessly integrates with these systems requires a deep understanding of data interoperability and technical compatibility between platforms. Neurology doctors can access real-time patient information and make more informed and rapid medical decisions with good integration.

The development of a telemedicine platform for neurology consultation should also pay attention to the usability aspect. This is important because the telemedicine platform will be used by various parties, including patients, doctors, and supporting medical personnel. An intuitive user interface, straightforward navigation, and easily accessible features will increase users' technology adoption and improve their platform experience. In addition, multi-platform support is also required so that users can access the telemedicine platform through various devices such as computers, tablets, or smartphones.

In developing telemedicine solutions, Agile Development methods have effectively addressed the complexity and frequent changes in information technology projects. Agile Development emphasizes team collaboration, responsiveness to change, and rapid product or system development iteration (Almeida et al., 2022; Al-Saqqa et al., 2020; Beecham et al., 2021; Behutiye et al., 2022; Humpert et al., 2022; Najihi et al., 2022; Shrivastava & Rathod, 2014). In developing a telemedicine platform for neurology consultations, the Agile Development approach allows the development team to continuously adapt to market needs, user feedback, and regulatory and technological changes that occur over time (Akhtar et al., n.d.; Altuwaijri & Ferrario, 2022; Beecham et al., 2021; Meiliana et al., 2023; Mishra & Alzoubi, 2023). Agile Development approach still needs to be completed, especially in the Indonesian context. Therefore, this research will significantly contribute to filling this knowledge gap and providing practical guidance for developers and healthcare providers interested in adopting telemedicine in their neurology practice.

The Agile Development method has several advantages, making it a practical approach to developing telemedicine platforms, especially for neurology consultations. One of the main advantages is its flexibility, which allows the development team to adapt quickly

to changing user needs and market dynamics. By dividing the project into small iterations called sprints, the team can focus on developing critical features and get regular feedback from stakeholders. This allows for continuous adjustments and improvements to the product, resulting in a telemedicine platform that is more responsive, easy to test, and compliant with user expectations and applicable regulations. In addition, the intense collaboration between the development team, doctors, and patients is another advantage that ensures that the resulting telemedicine platform is technically perfect, meets actual clinical needs, and can significantly improve the user experience.

This research focuses on designing a telemedicine platform specifically for neurology consultations using an Agile Development approach. The main objective is to ensure that the platform is effective in facilitating interactions between doctors, patients, and medical teams, secure, responsive to changing needs, and easy to use. The contribution of this research will open the door for further development of telemedicine technology, improve the efficiency and quality of remote neurology services, and provide practical guidance for the development of telemedicine platforms in various other medical specialties.

METHODS

In this research, three main stages as shown in Figure 1, User Requirements Analysis, Application Development, and User Acceptance Evaluation, form a holistic framework to design and implement a customized telemedicine platform for neurology consultations. The User Requirements Analysis stage focused on deeply understanding the needs and expectations of the primary users. In contrast, the Application Development stage utilized an Agile Development approach to translate these needs into platform design and functionality. Meanwhile, the User Acceptance Evaluation stage became a critical step in validating the feasibility and acceptance of the platform by actual users by conducting trials, collecting feedback, and iterative improvements to ensure the quality and success of the telemedicine platform in improving access and quality of remote neurology consultation services.

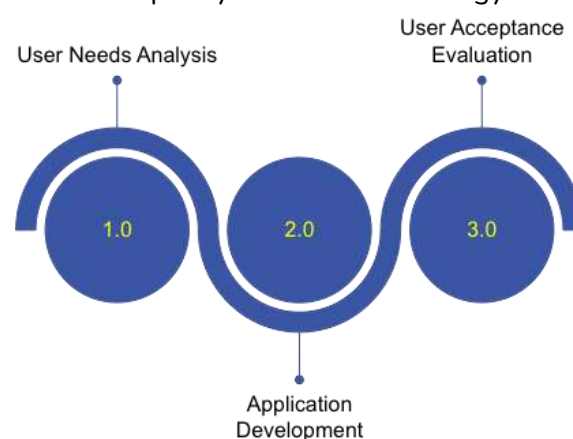


Figure 1. Research Stages

User Needs Analysis

At this stage, the focus is on identifying the critical needs of users such as neurology doctors, patients, and supporting medical teams. By conducting surveys, interviews, and focus group discussions, the goal is to understand the neurology consultation process and user preferences for the telemedicine platform and collect functional and non-functional requirements that will form the basis for platform development.

Application Development

This stage involves translating user requirements into designing and developing an effective telemedicine platform. By applying the Agile Development method, prototyping, testing functionality, and integrating systems will be carried out iteratively to ensure the platform can meet the desired needs and quality standards.

User Acceptance Evaluation

Once the telemedicine platform has been developed, this evaluation phase aims to test the platform's acceptance and performance by real users. Beta trials, feedback collection, data analysis, and iterative improvements will be conducted to ensure that the telemedicine platform works well and can be accepted and used comfortably by doctors, patients, and medical teams.

RESULTS AND DISCUSSION

User Needs Analysis

During the User Needs Analysis Phase, a series of activities were conducted to understand the needs and expectations of key stakeholders, namely neurology physicians, patients, and supporting medical teams regarding using a telemedicine platform for neurology consultations. It started with identifying these stakeholders and collecting information on their needs for the telemedicine platform. Through surveys and in-person interviews with neurology physicians, the neurology consultation process, information critical to diagnosis and treatment, and challenges faced in daily practice were understood. Focus Group Discussions (FGDs) were also held with patients to understand their perspectives on the use of telemedicine platforms. Patients' preferences regarding data security and privacy, comfort in using the platform, and constraints they may experience, such as technological limitations or the need for additional support, were highlighted in these discussions. The results of these activities were documented in detail, covering functional and non-functional requirements, prioritization of features desired by users, and usage scenarios of the telemedicine platform in diverse neurology consultation situations. This documentation provided a strong foundation for the later stages of the telemedicine platform development. With a deep understanding of the users' needs and challenges, the designed telemedicine platform can optimally meet the users' expectations and needs.

Table 1. Data Collection Results

Activities	Description
Stakeholder Identification	This phase involves identifying and gathering data from key stakeholders involved in the use of telemedicine platform for neurology

Surveys and Interviews with Neurologists	consultations, including neurologists providing services, patients receiving services, and supporting medical teams involved in patient information management. Through surveys and direct interviews with neurologists, this stage aims to gain in-depth understanding of the neurology consultation process, the information needs required for diagnosis and treatment, and the challenges they face in daily practice, such as managing medical history and data integration.
Focus Group Discussions (FGD) with Patients	Focus Group Discussions (FGD) are conducted with patients to understand their perspectives on using the telemedicine platform in neurology consultations. These discussions include patient preferences regarding data privacy, usability of the platform, and potential challenges they may encounter in its use.
Requirements Documentation	The results of this needs analysis are documented in detail, including functional and non-functional requirements expressed by stakeholders, desired feature priorities by users, and usage scenarios of the telemedicine platform in various neurology consultation situations. This documentation serves as the foundation for further development.

Table 1 shows four activities carried out in the User Needs Analysis Stage for the development of the neurology consultation telemedicine platform. First, stakeholder identification is an essential first step in understanding who uses this telemedicine platform. Neurology physicians, patients, and supporting medical teams were identified as the primary stakeholders who play a role in the remote neurology consultation process. Secondly, through surveys and interviews with neurology physicians, significant information was obtained regarding the neurology consultation process, the information needed for diagnosis and treatment, and barriers to implementing this telemedicine technology. Third, Focus Group Discussions (FGDs) with patients provided a deeper understanding of users' preferences in using the telemedicine platform, including essential privacy needs and practical barriers they may encounter. Finally, the requirements documentation described the results of a detailed analysis of functional and non-functional requirements, feature priorities expressed by stakeholders, and scenarios of using the telemedicine platform in different neurology consultation situations. This documentation serves as a critical reference in the next stage of development to ensure the telemedicine platform can optimally meet the expectations and needs of users.

Application Development

During the Application Development Stage, various vital steps were taken to ensure the success of the telemedicine platform for neurology consultations, as shown in Figure 2. First, user requirements were translated into a telemedicine system architecture design that included the database structure, friendly user interface (UI/UX), and supporting business logic. Next, the Agile Development method was used to break down the application devel-

opment into iterative sprints, allowing developers to focus on key features in each iteration by receiving direct feedback from stakeholders. The outcome of this process was the creation of an initial prototype of the telemedicine platform that reflected the agreed design. Finally, thorough functional and system integration testing was conducted to ensure that the telemedicine platform functions correctly and securely and integrates with existing health systems, including trials of consultation features, data security, and integration with electronic medical records and other health information systems before its official launch.

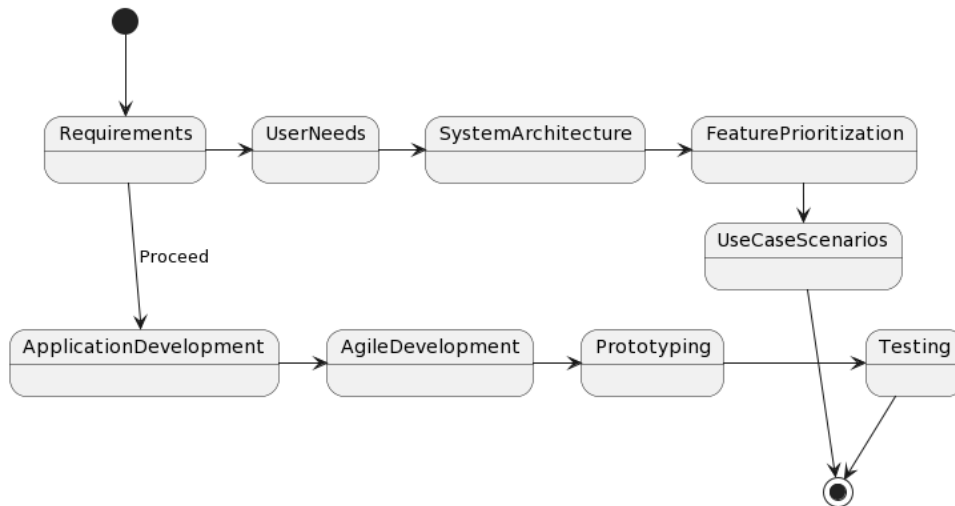


Figure 2. State Diagram

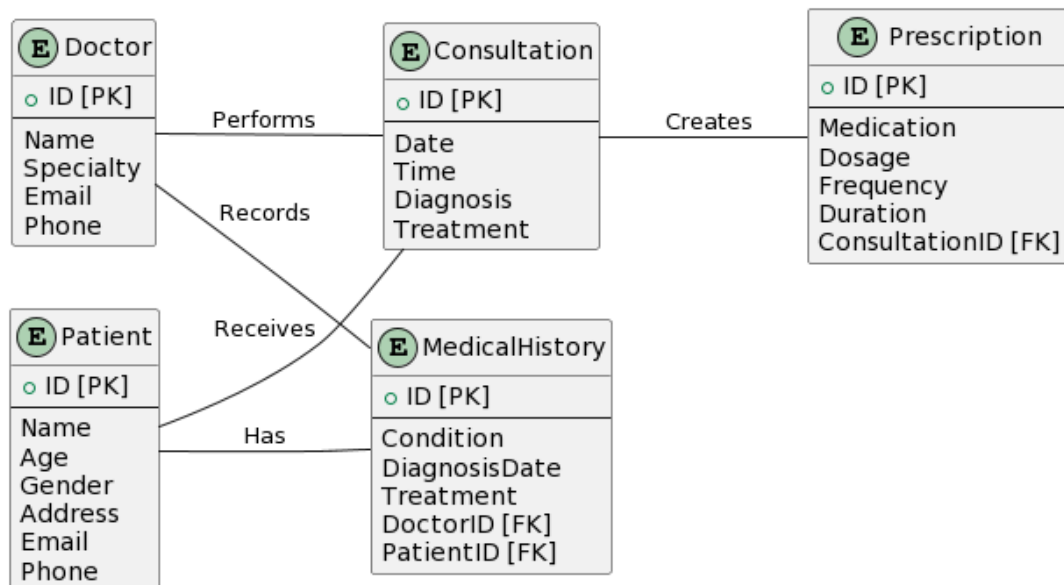


Figure 3. ERD

The Entity Relationship Diagram (ERD) in Figure 3 illustrates the data structure required to manage information related to neurology consultations between doctors and pa-

tients. Several main entities are identified in this diagram. First is the Doctor entity, which includes attributes such as ID, Name, Specialization, Email, and Phone Number. These attributes are used to identify and manage information about the doctor involved in the neurology consultation. Next, the Patient entity has attributes such as ID, Name, Age, Gender, Address, Email, and Phone Number, which are used to record patients' personal and contact information receiving neurology consultation services. The Consultation entity represents every detail of the neurology consultation between the doctor and the patient, with attributes such as ID, Date, Time, Diagnosis, and Treatment.

This allows the management of important information from each consultation that occurs. Furthermore, the Prescription entity represents the medication prescription given by the doctor to the patient during the neurology consultation, with attributes such as ID, Drug, Dose, Frequency, Duration, and Consultation ID. This allows for detailed recording of the prescription given to the patient and associated with the consultation in question. Finally, the MedicalHistory entity records the patient's medical history, with attributes such as ID, Condition, Diagnosis Date, Treatment, Doctor ID, and Patient ID. This entity allows the recording of information about the patient's health condition, the diagnosis that has been made, the treatment that has been given, and information about the treating doctor and the patient in question. This ERD provides a comprehensive overview of the data structure required to manage the health information and neurology consultation process between doctors and patients in the telemedicine platform application. The relationships between the entities make it possible to organize and manage data efficiently, ensuring the continuity of quality health services for users of this application.

In Sprint Planning, figure 4, the development of the telemedicine platform application is planned and executed in three different sprints. The first sprint starts with the user requirements analysis stage (Analyzing Requirements), where the project team studies and translates user requirements into precise specifications. The next step was user interface design (Designing UI), where the visual and functional concepts of the application were translated into an implementable design. After that, the team focuses on developing key features (Developing Features) based on the previously agreed design. The first sprint also includes an initial testing phase (Testing) of the developed features to ensure quality and compliance with user requirements. The second sprint starts with the Refining Requirements phase, where the team evaluates and refines the existing requirements specification based on feedback from the previous sprint or updates to new requirements. Next, the team focuses on designing the application's backend to support the previously designed features.

The next step is the development of additional functionality (Developing Functionality) that integrates with the prepared backend design. The second sprint also involves testing the new features developed to ensure compliance with user needs and overall application quality. The third sprint begins with enhancing the UI based on user feedback and design evaluation. Next, the team focused on improving the app's performance (Improving Performance) to ensure optimal responsiveness and speed during use. The last stage is fi-

nalizing the features that have been developed and conducting thorough testing before the official launch of the application.

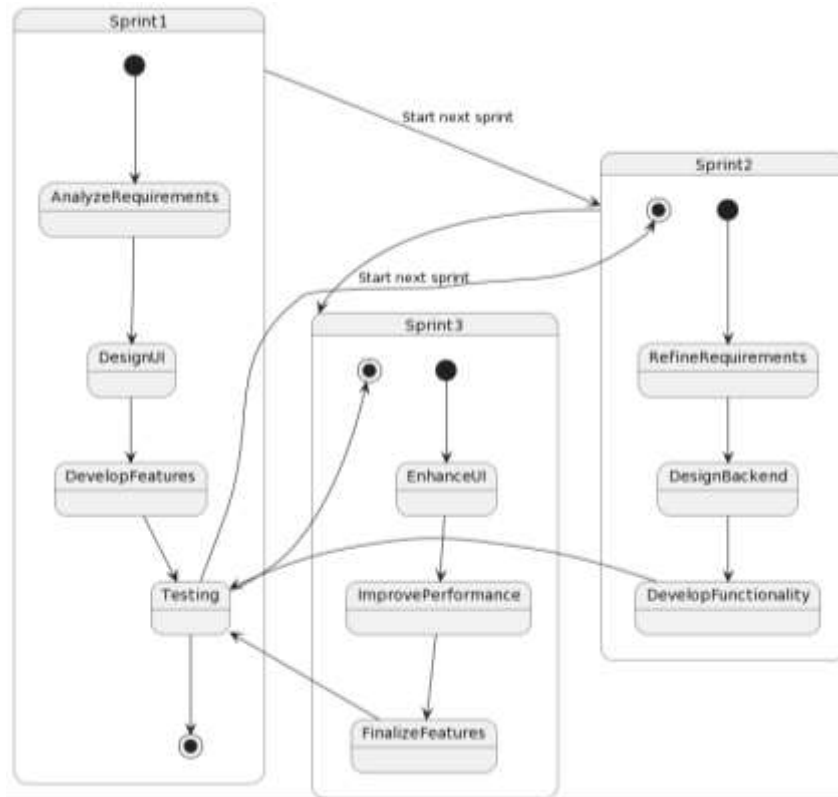


Figure 4. Sprint Planning

The third sprint also involved a final evaluation of all application features and functions to ensure quality and compliance with user needs. This sprint planning approach to app development allowed the project team to focus on specific parts of the development in each iteration, aiming to produce a comprehensive, responsive, and high-quality telemedicine app. Each sprint produces outputs that can be evaluated, corrected, and improved before moving on to the next stage of development, thereby reducing project risk and increasing the efficiency of application development.

User Acceptance Evaluation

Beta trials were conducted with a limited group of neurology doctors, patients, and supporting medical teams to test the telemedicine platform's usability, performance, and security. In this pilot test, various platform features and functionalities were thoroughly evaluated to ensure that users could easily access, use, and utilize the platform effectively. Feedback was obtained from users regarding their experience in using the telemedicine platform. This includes evaluation of usability, comfort of use, satisfaction with the features provided, and suggestions for desired improvements or enhancements from the perspective of the actual users. Collecting this feedback forms the basis for understanding the actual needs and preferences of the users. Feedback data from users was analyzed in depth to identify areas that needed to be fixed or improved on the telemedicine platform. Iterative

improvements were made based on the user acceptance evaluation results, aiming to incrementally improve user experience, optimize performance, and enhance platform security. A final evaluation was conducted to measure the effectiveness of the telemedicine platform in improving the accessibility and quality of remote neurology consultation services. This evaluation involved a re-evaluation in terms of usability, performance, security, and the platform's positive impact on neurology healthcare as a whole. The results of this evaluation formed the basis for determining the platform's readiness for official launch and more comprehensive scale implementation.

CONCLUSION

This research has resulted in a significant contribution to the development of a telemedicine platform specifically for neurology consultations. By comprehensively identifying user needs through in-depth analysis, the platform can provide features that meet the expectations of neurology doctors, patients, and supporting medical teams. The Agile Development method applied in this research also provides advantages in development efficiency, allowing for rapid improvement and adaptation to changing user needs and technological developments. The user acceptance evaluation stage involving beta trials and feedback collection provided valuable insights into improving the telemedicine platform's usability, performance, and security. The platform can be continuously improved through data analysis and iterative improvements to provide a better user experience. The final evaluation results show that this telemedicine platform effectively improves the accessibility of remote neurology consultation services, ultimately improving patients' quality of life and supporting physician practices in providing better and more affordable care. Thus, this study makes a meaningful contribution to improving neurology healthcare services by effectively utilizing telemedicine technology.

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