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Optimizing Patient Appointment Scheduling in Neurology Clinics Using Agile-Based Appointment Management System

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ABSTRACT
Patient appointment management is a critical aspect of neurology clinic operations, especially given the complexity of patient care and the increasing number of patients requiring specialized attention. Capacity and efficiency challenges in scheduling negatively impact patient waiting times and optimal access to care. This research adopts an Agile approach in developing an information technology-based appointment management system to address scheduling issues in neurology clinics. The research methods include a literature study, interviews with relevant parties, patient surveys, system prototype development, and end-user evaluation. The implementation of the Agile-based appointment management system resulted in a significant reduction in patient waiting time and increased patient satisfaction. Data analysis showed that the use of information technology in scheduling improved the efficiency of using clinic resources and minimized the risk of delays in diagnosis and treatment. This study contributes to developing an adaptive and effective appointment management system in neurology clinics. It provides a foundation for developing better systems to improve healthcare quality and patient satisfaction in the long term.

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INTRODUCTION

Appointment scheduling in neurology clinics is a complex problem in health care. This is due to several factors, including increased patients accessing neurology services. The growth of the elderly population and the increase in complex neurological cases are the leading causes of this surge. This increase in the number of patients is significant, especially regarding waiting times and service accessibility(Hinault et al., 2023; A. Lin & Espay, 2021; J. J. Lin et al., 2023; Vucic et al., 2023). Long waiting times can be uncomfortable for patients and potentially increase the risk of delayed diagnosis and treatment, affecting the care outcome. In addition, limited access to services can also prevent patients from receiving timely care, especially for those who require immediate treatment in emergency or urgent conditions. Therefore, finding an effective solution to manage appointment scheduling in neurology clinics is essential to improve efficiency and provide quality care to patients(Demaerschalk et al., 2023; Miller et al., 2023; Rangel et al., 2022; Roulet Perez, 2023).

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Managing neurological patients is a complex challenge and requires a comprehensive approach. In a neurology clinic, patients often face multi-faceted health problems, ranging from central nervous disorders to neuromuscular disorders. Therefore, the diagnosis and treatment of these patients requires a diverse medical team, including neurologists, neurosurgeons, radiologists, and physical and occupational therapists(Charalambous et al., 2023; Kaji, 2023; Lewis et al., 2024; Yakub et al., 2023; Yip et al., 2023). This medical teamwork is key in managing complex cases, as it allows for a holistic understanding of the patient's condition and more effective treatment. However, neurology clinics often face capacity and efficiency challenges. Limited space, doctor consultation time, and other resources can affect scheduling patient appointments. Non-optimal scheduling can lead to delays in service, increased patient waiting time, and patient dissatisfaction. In this context, there is a need for an effective solution in neurology patient scheduling management, which not only addresses capacity and efficiency challenges but also improves the patient experience in receiving appropriate and quality care.

Improving the patient experience in the context of healthcare is a significant focus of many healthcare institutions, including neurology clinics. As technology and new approaches to healthcare management evolve, improving patient experience is not only a goal but also a pressing need(Evans et al., 2021; Matías-Guiu et al., 2010; Migliorelli et al., 2023; Waddell et al., 2023). By improving patient satisfaction and their perception of the quality of care, clinics can build better relationships with patients, increase loyalty, and strengthen their reputation in the healthcare industry. Furthermore, improved patient experience can also minimize the risk of delays in diagnosis and treatment, thereby directly impacting treatment outcomes and prognosis of neurology patients.

In the era of information technology advancement, healthcare has undergone a significant transformation(Bhat et al., 2023; Mahdi et al., 2023). One major aspect of this transformation is the implementation of health information systems (EHRs), which have changed how clinics and hospitals manage patient data and service processes. This technology enables more efficient storage and access to patient medical records and facilitates the utilization of technology to manage patient queues and doctor schedules effectively. With the adoption of this technology, clinics can optimize appointment arrangements, reduce patient waiting times, and improve responsiveness to patient needs. The Agile-based Appointment Management System concept is also one of the promising innovations in developing a more adaptive and responsive healthcare system. Agile principles in software development, such as team collaboration, rapid iteration, and focus on user needs, can be effectively applied in healthcare appointment management(Beecham et al., 2021; Dingsøyr et al., 2012; Gutierrez et al., 2019; Wiechmann et al., 2022). The flexibility and adaptability of Agile systems allow clinics to be more responsive to changes, unique needs, and dynamics that occur in patient appointment management. Thus, incorporating information technology advancements, EHR implementation, and Agile concepts in appointment management systems can bring significant benefits to neurology clinics in improving efficiency, quality of care, and overall patient experience.

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The main objective of this study was to investigate and implement an Agile-based appointment management system in a neurology clinic, focusing on improving efficiency, quality of care, and overall patient experience. This research aims to identify the main challenges in appointment scheduling in neurology clinics, understand Agile principles in system development, and adapt those principles to the context of healthcare appointment management. In addition, this study also aims to evaluate the impact of the Agile system implementation on patient waiting time, time availability for patients with emergencies, as well as patient satisfaction and overall clinic productivity. The main contribution of this research is developing and implementing an Agile-based appointment management system that can improve the operational efficiency of neurology clinics. By introducing an Agile approach to appointment scheduling, this study is expected to reduce patient waiting time, increase availability for emergency patients, and improve patient satisfaction and overall clinic productivity. In addition, this study can also provide insights and practical guidance for other clinics that wish to adopt or improve their appointment management system by utilizing Agile principles. Thus, this study is expected to significantly contribute to improving the efficiency and quality of healthcare in neurology, as well as provide a basis for further development in patient appointment management.

METHODS

The research followed three main systematic and comprehensive stages, as shown in Figure 1, starting with User Needs Analysis, which involved a series of methods such as an in-depth literature study, intensive interviews with relevant parties, focus groups to gain insights from various perspectives, and patient surveys to formulate a comprehensive understanding of user needs and problems encountered in neurology clinic appointment management. The second stage, Application Development, is the core of this research, where the design and development of an Agile-based appointment management system are meticulously carried out, including the implementation of prototypes that are continuously improved and refined based on feedback from users, as well as thorough training for system users. The final stage, User Acceptance Evaluation, was an important milestone in testing the feasibility and effectiveness of the system, involving rigorous functional testing to ensure all features performed as expected and end-user testing involving active participation from stakeholders, both patients and clinic staff, to obtain immediate feedback that formed the basis for ongoing system updates and the production of an in-depth and informative final evaluation report. As such, this holistic and structured approach provides a solid foundation for developing an adaptive, responsive, and effective appointment management system in neurological clinics and valuable insights for the future development of similar systems.

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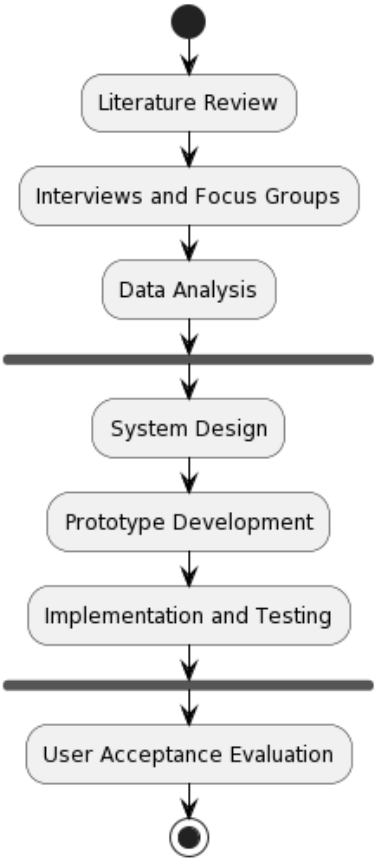

Figure 1. Research Stages

User Needs Analysis

The first stage in this research was User Needs Analysis, which began with a literature study to deeply understand the challenges faced in neurology clinic appointment management, Agile concepts, and the latest technologies in healthcare. The next activity was to conduct interviews and focus groups with doctors, nurses, and administrative staff of the neurology clinic to gain a deeper understanding of the needs and problems in scheduling appointments. In addition, a survey was also conducted with neurology patients to gather their feedback and concerns on the scheduling process. All data collected was then analyzed to identify essential user needs and issues to be addressed in the system development.

Application Development

The second stage is Application Development, where the design of the Agile-based appointment management system is developed based on the results of the user needs analysis. A system prototype was also built to be tested and evaluated in a neurology clinic environment. The next activity was to implement the system at the clinic and conduct internal trials to ensure its functionality and effectiveness. User training was also conducted for

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clinic staff on using the new system and Agile principles applied in appointment management.

User Acceptance Evaluation

The third stage is User Acceptance Evaluation, which includes functional testing of the system to ensure all features work correctly according to user requirements. End-user testing is also conducted by inviting a few patients and clinic staff to use the system in real-life situations and then collecting their feedback and evaluation of the experience. The results of this evaluation were analyzed to update the system based on the feedback and recommendations provided before being compiled into a final user evaluation report along with research results and recommendations for further development.

RESULTS AND DISCUSSION

User Needs Analysis

The outcome of this research is an in-depth understanding of the challenges in appointment management in neurology clinics, the concept of Agile, and the latest technology in healthcare obtained through a literature review. Through interviews with doctors, nurses, and administrative staff of the neurology clinic, it was found that the main challenges in appointment scheduling are limited resources and the complexity of patient cases. In addition, a survey of neurology patients revealed that long waiting times and lack of information about doctors' schedules were the main problems they faced. The data analysis conducted on the literature study results, interviews, focus groups, and surveys identified that the primary user needs are more efficient scheduling, reduced patient waiting time, and improved communication about the doctor's schedule. Problems that need to be addressed include limited resources, the complexity of patient cases, and the need for more transparency in appointment scheduling.

Table 1 summarises the results of the various activities undertaken in the study, from literature review to data analysis, to gain a comprehensive understanding of the challenges and needs in appointment management in neurology clinics.

Table 1. Data Collection Results

Activities	Results
Literature Study	In-depth understanding of the challenges in neurology clinic appointment management, Agile concepts, and the latest technology in healthcare.
Interviews and Focus Groups	Limited resources and the complexity of patient centers were identified as critical challenges. It was also found that waiting time and lack of information on doctors' schedules were problems.
Patient Survey	Feedback from neurology patients regarding long waiting times and the need for more information on doctors' schedules were the main problems encountered.
Data Analysis	Identify critical user needs such as more efficient scheduling, reduced patient waiting time, and improved communication regarding doctors'

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Activities	Results
	schedules. Issues that need to be addressed include limited resources, the complexity of patient cases, and the need for more transparency in appointment scheduling.

From the analysis of Table 1, the study has identified several key aspects related to appointment management in neurology clinics. The main challenges faced were limited resources and the complexity of patient cases, which were consistent findings from the interviews and focus groups. On the other hand, the survey of neurology patients highlighted the issue of long waiting times and lack of information regarding doctors' schedules as the main problems they experienced. This suggests there needs to be more clarity between patients' expectations and the reality of the service provided. Data analysis revealed vital user needs, including more efficient scheduling, reduced patient waiting times, and improved communication regarding doctors' schedules. However, some issues needed to be addressed, such as limited resources, the complexity of patient cases, and the need for more transparency in appointment scheduling. This analysis provides a comprehensive understanding of the challenges, needs, and issues faced in appointment management in neurology clinics, which will serve as a basis for developing more effective and user-friendly solutions.

Application Development

The results of the Application Development phase of this research include several vital processes. Firstly, an Agile-based appointment management system design was developed by considering the identified essential user needs. The system design incorporated Agile principles, such as team collaboration, rapid iteration, and focus on user needs, thus ensuring the system's suitability and relevance to the neurology clinic's operational needs. Furthermore, a system prototype was successfully built as a first step before widespread implementation. The prototype was designed to be trialed and evaluated, which is an essential step in ensuring the feasibility and functionality of the system before its full implementation in the clinic environment. Subsequently, the system was implemented in a neurology clinic environment and underwent internal testing to ensure its functionality, performance, and effectiveness. The final step of this stage was user training for clinic staff on using the newly developed system and understanding the Agile principles upon which the system was developed. The overall outcome of the Application Development phase is a strong foundation for implementing an Agile-based appointment management system in the neurology clinic, focusing on efficiency, responsiveness, and quality of care provided to patients.

Figure 2 visually illustrates the stages of the application development life cycle. The diagram starts with the initial "Draft" stage, which involves analyzing the requirements and planning the application design. After the Draft stage, the application enters the development phase, which includes implementation planning, code writing, and testing. The testing aims to ensure that the application functions correctly and by the specifications set.

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After the application has been developed, the diagram shows that the application can enter the implementation phase. This stage involves implementing the application in a production environment, often called the Deploy stage. Once implemented, the application enters the maintenance stage, which includes bug fixes and updates that may be required to maintain optimal application performance. In addition, the diagram also highlights advanced stages such as continued testing after maintenance, enhancing the application by adding new features, and regular updates. All these stages are essential to ensure the application remains relevant and functional and fulfills user needs over time. This state diagram provides a clear picture of the sequence of stages in app development and how each stage is interrelated in the overall app development lifecycle.

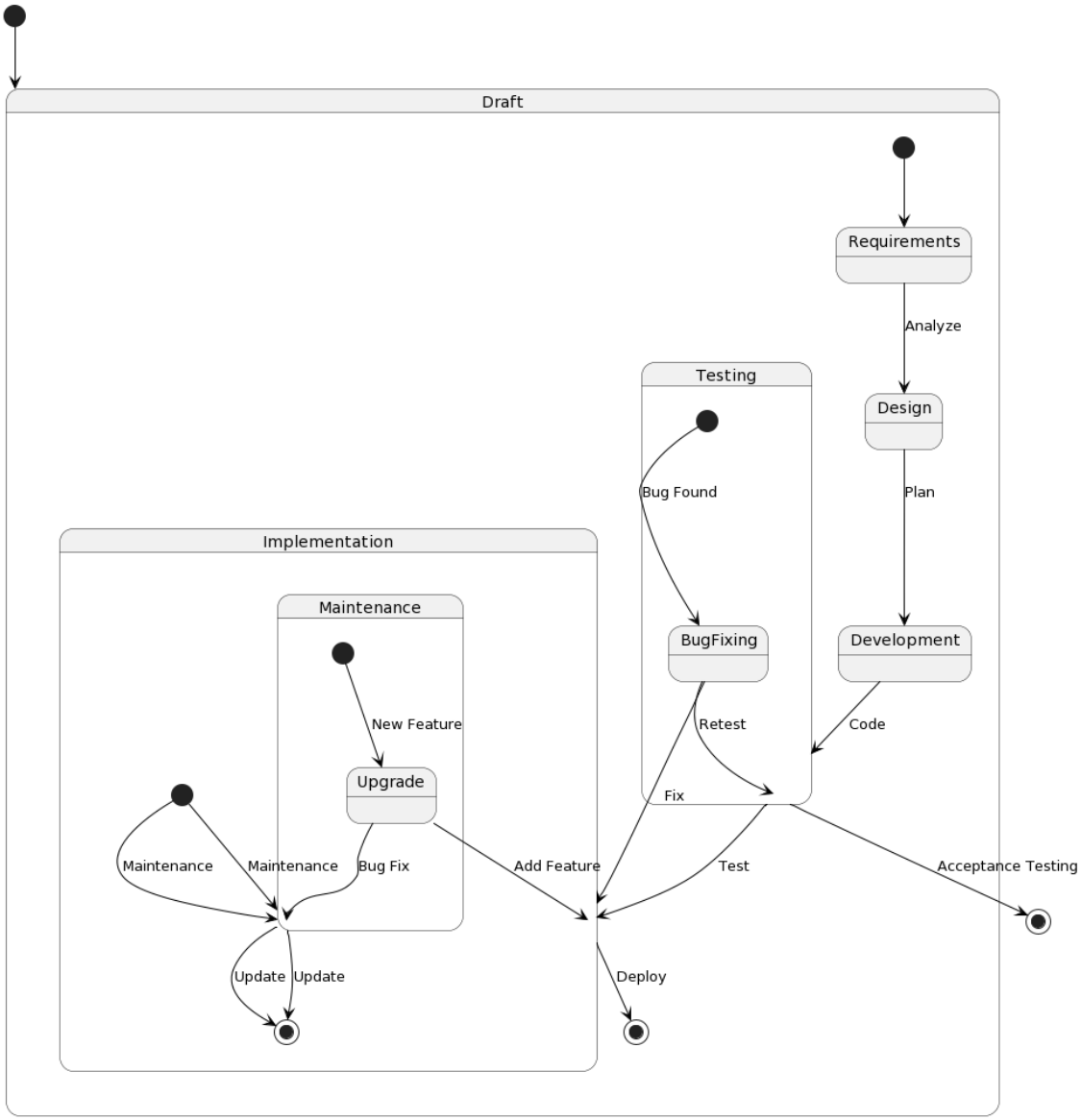

Figure 2. State Diagram

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The Entity-Relationship Diagram (ERD), Figure 3, displays the complex data structure for the clinic application. This ERD analysis starts with the User entity representing the clinic application's user or users. Each user has attributes such as UserID for unique identification and identity and contact information such as FirstName, LastName, Email, and Phone. Furthermore, the Appointment entity represents an appointment between a doctor and a patient, with the AppointmentID attribute as the primary key and the Date, Time, Status, and Note attributes that reflect appointment-related information.

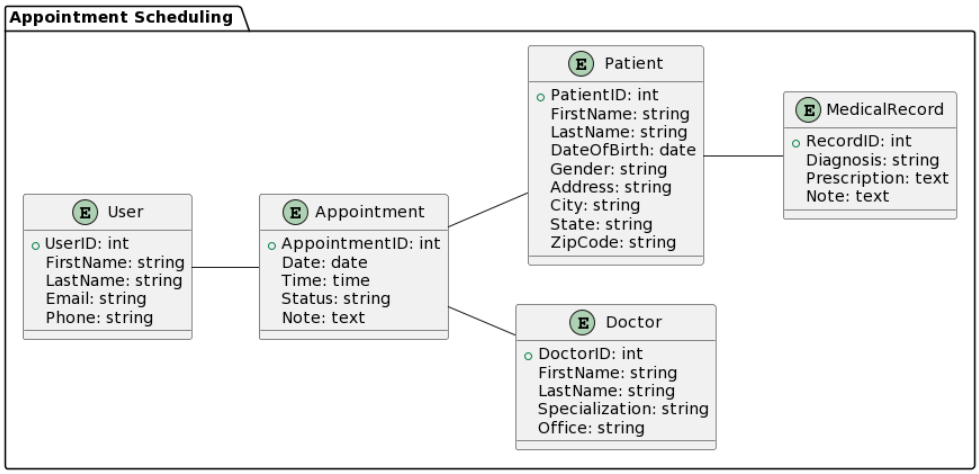

Figure 3. ERD

In the context of doctors, the ERD includes a Doctor entity that describes information about doctors in the clinic. This entity has attributes such as DoctorID for unique identification and information such as the doctor's specialization and office. Meanwhile, the Patient entity represents information about patients, with attributes such as PatientID for unique identification and identity information, date of birth, address, and more.

The MedicalRecord entity is an essential part of the ERD, which records a patient's medical or health records. This entity has the attributes Diagnosis for recording medical diagnoses, Prescription for prescribing medication, and Note for additional notes related to medical records. The relationships between the entities in the ERD describe the logical connections between the data in the clinic application. For example, the relationship between the Appointment, Doctor, and Patient reflects the relationship between the appointment, the doctor, and the patient who has the appointment. This ERD analysis provides a clear picture of the data structure required to develop a comprehensive and efficient clinic application.

Figure 4 shows the set of activities planned to be carried out in the four weeks of development. In Week One, the main focus was on designing the user interface (UI/UX), creating the login and registration pages, and establishing the database structure that forms the system's foundation. The implementation of user management and appointment management integration also began this week, coupled with testing and debugging to ensure the initial quality of the application. In Week Two, the focus shifted to implementing doctor and patient management, developing reports and analytics features, and integrating notifi-

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cations and reminders. In addition, final testing and debugging were conducted to fine-tune the pre-built features and application documentation to facilitate user and developer understanding. Week Three was devoted to overall application testing, performance optimization, and system integration to the central database. A thorough test of the application's functionality was also conducted to ensure all features ran well and aligned with expectations. The last week was the preparation stage for the launch of the app to the clinics. Here, user training (clinic staff), launch preparation, and the app's official launch to the clinics are conducted. After the launch, an initial monitoring and evaluation is conducted to identify any problems or improvements that need to be made.

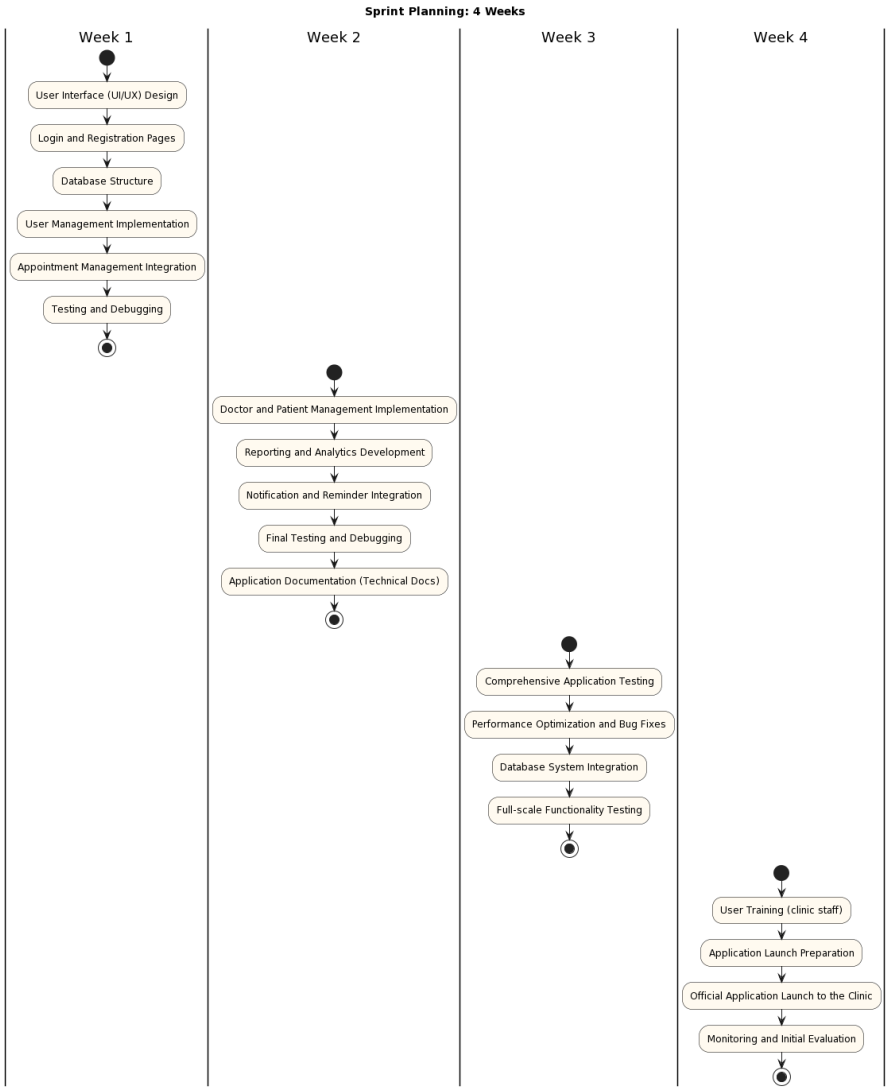

Figure 4. Sprint Planning

User Acceptance Evaluation

In the User Acceptance Evaluation stage, evaluations ensure that the developed clinical application complies with quality standards and effectively fulfills user needs. Function-

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al Testing is conducted to identify and fix functional issues that may occur before the official launch of the application. The results of these tests become the basis for optimizing the application's performance and ensuring all features run correctly according to user requirements. Next, End User Testing invites a small number of patients and clinic staff to use the system in real situations. The evaluations obtained from the end users become the primary reference in evaluating the user interface, ease of use, and other relevant functional needs. The results of the end-user evaluation analysis were then used to update the system based on the feedback and recommendations provided. These updates aim to fix any issues found, improve application performance, and enhance the overall user experience. In addition, preparing the end-user evaluation report is an essential step in documenting the research results, key findings, improvement recommendations, and suggestions for further development. This report guides the development team in customizing the system for all clinic users before the app's official launch.

CONCLUSION

Based on the research on appointment scheduling optimization in neurology clinics using an Agile-based Appointment Management System, this approach has great potential to improve the efficiency and quality of health services in neurology clinics. In the background of the study, the complexity of managing neurology patients, the growing number of patients, and the capacity and efficiency challenges in scheduling have been highlighted. Therefore, using an Agile-based Appointment Management System is an effective solution to overcome these problems. The application of Agile in the development of neurology clinic applications has a significant positive impact, such as reducing patient waiting time, increasing patient satisfaction, and optimizing the use of clinic resources. Through the stages of research, which include literature study, interviews, surveys, application development, and user evaluation, an in-depth understanding of user needs and challenges faced in appointment management is obtained. Thus, the conclusion of this study shows that implementing an Agile-based Appointment Management System has great potential to improve efficiency, service quality, and patient satisfaction in neurology clinics. However, it is necessary to conduct continuous evaluations and adjustments according to user feedback to ensure the suitability and sustainability of the implemented system.

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