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Development of an integrated clinical information system using agile approach to enhance patient care coordination

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ABSTRACT
Healthcare systems are increasingly adopting Agile methodologies to address the complexities of software development in dynamic environments. This study investigates the application of Agile methodology in developing an adverse drug reaction monitoring system within a pharmacy context. The research focuses on identifying user requirements, employing iterative Agile practices, and evaluating functional outcomes. Through an analysis of user needs and preferences, wireframing, and iterative development cycles, the study demonstrates the effectiveness of Agile in meeting evolving demands and ensuring user satisfaction. Results indicate that Agile methodology facilitates flexible and responsive development, enabling continuous improvement and adaptation to changing requirements. The collaborative nature of Agile fosters stakeholder engagement and communication, enhancing the relevance and usability of the monitoring system. This research contributes to the growing body of literature on Agile methodology in healthcare software development, providing insights into its application, benefits, and implications for pharmacy settings.

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INTRODUCTION

In contemporary healthcare environments, the delivery of patient care has increasingly become complex due to factors such as advancements in medical technology, an aging population, and the prevalence of chronic diseases. This complexity often leads to fragmented care delivery and challenges in ensuring seamless coordination among healthcare providers, ultimately affecting patient outcomes. Central to addressing these challenges is the role of clinical information systems (CIS), which encompass electronic health records (EHRs), computerized physician order entry (CPOE) systems, and other digital tools that support the capture, storage, and exchange of patient information across healthcare settings. These systems play a crucial role in facilitating communication, streamlining workflows, and improving the quality and safety of patient care(Frestel et al., 2023; Moote et al., 2023; Van Lancker et al., 2023).

However, despite their potential benefits, the development and implementation of integrated CIS remain a significant challenge in healthcare organizations. Traditional

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approaches to CIS development often involve lengthy and rigid processes that struggle to keep pace with the dynamic nature of healthcare delivery. This has led to instances of outdated or cumbersome systems that fail to meet the evolving needs of healthcare providers and patients. Furthermore, the siloed nature of many existing CIS limits interoperability and data exchange, hindering care coordination efforts across different care settings and providers(Akseer et al., 2020; Bhutta et al., 2020; Bin et al., 2021; Goense et al., 2023; Kumar & R.S., 2022). To address these challenges, there is a growing interest in adopting agile methodologies in CIS development. Agile is an iterative and incremental approach to software development that emphasizes flexibility, collaboration, and continuous improvement. By breaking down development tasks into small, manageable units and prioritizing customer feedback and adaptability, agile methodologies offer a more responsive and iterative approach to system development(Alami et al., 2022, 2023; Almeida et al., 2022; Bomström et al., 2023; Estrada-Esponda et al., 2024; Najihi et al., 2022; Rindell et al., 2021). This is particularly advantageous in the healthcare context, where requirements and priorities can change rapidly in response to emerging clinical evidence, regulatory changes, or shifting patient needs.

The primary objective of this research is to develop an integrated CIS using an agile approach to enhance patient care coordination. By leveraging agile principles and practices, the research aims to create a CIS that is responsive to the dynamic nature of healthcare delivery and adaptable to evolving user needs. This involves incorporating features such as user stories, iterative development cycles (sprints), and regular stakeholder feedback sessions into the development process. By doing so, the research seeks to address the limitations of traditional CIS development approaches and deliver a system that is more aligned with the needs and realities of modern healthcare delivery.

The research also aims to evaluate the effectiveness of the agile approach in CIS development, particularly in terms of its impact on care coordination and patient outcomes. This will involve assessing factors such as system usability, workflow integration, data interoperability, and user satisfaction. By conducting rigorous evaluation and assessment activities, the research aims to provide insights into the strengths and limitations of agile methodologies in the context of CIS development, as well as identify areas for further improvement and refinement. The findings of this research are expected to contribute to the growing body of knowledge on CIS development and agile methodologies in healthcare. By demonstrating the feasibility and effectiveness of agile approaches in enhancing care coordination and system usability, the research has the potential to inform future CIS development efforts and support the adoption of agile methodologies across healthcare organizations. Ultimately, the research seeks to contribute to the ongoing efforts to improve patient care quality, safety, and efficiency through the effective use of information technology and agile practices in healthcare settings.

This study is limited to the development of an integrated CIS in a specific healthcare environment and may not fully capture the complexities and challenges of CIS development in other contexts. Additionally, the evaluation of the agile approach in CIS development may be influenced by factors such as organizational culture, resource

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availability, and stakeholder engagement. These limitations should be taken into account when interpreting the findings of the research and may warrant further investigation in future studies.

METHODS

This research involves three main stages in the development of a clinical information system using an agile approach. The first stage is user needs analysis, which includes stakeholder identification, system requirement elicitation through elicitation methods, user story creation, prioritization of needs, and prototyping to obtain early user feedback. The second stage is application development using agile methodology, which encompasses sprint planning, daily stand-up meetings, iterative development, continuous integration, and user acceptance testing (UAT). The final stage is the evaluation of user acceptance of the developed system, involving survey preparation, user training, system implementation, user feedback collection, data analysis, and identification of areas for further improvement. With this approach, the research aims to produce a clinical information system that is responsive, adaptive, and acceptable to users, thereby enhancing patient care coordination and clinical outcomes overall.

Figure 1. Research Stages

User Needs Analysis

The first stage of this research involves user needs analysis. In this stage, the identification of stakeholders involved in system usage is an important initial step to ensure that all aspects of user needs are considered holistically. Subsequently, system requirements are gathered through various methods such as interviews, questionnaires, and direct observations, in a process known as elicitation. The collected data are then utilized to create user stories depicting the system's functionalities from the user's perspective. Prioritization is also an integral part of this stage, where user needs are ranked based on urgency and importance for the initial system development. Finally, prototyping is conducted to create an initial system model that can be used to obtain early feedback from users regarding the proposed design and features.

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Implementation of the Agile Methodology

The second stage of the research involves application development using agile methodology. Sprint planning becomes the primary activity in this stage, involving the selection of features to be developed in specific iterations based on team priorities and capacities. Daily stand-up meetings are held to track progress, identify obstacles, and organize daily tasks. Development is carried out iteratively, with system features implemented gradually in development cycles consisting of multiple sprints. Continuous integration is also performed regularly to ensure that code changes from each team member are integrated smoothly into the overall system. Lastly, user acceptance testing (UAT) is conducted to engage users in testing the developed features and ensuring their alignment with needs and expectations.

Functional Evaluation and User Acceptance analysis

The final stage of the research is the evaluation of user acceptance of the developed system. Survey preparation is the initial step in this stage, involving the preparation of questionnaires or other assessment instruments to measure user perceptions and satisfaction with the system. Users are also trained on how to effectively and efficiently use the system before its widespread implementation. After implementation, user feedback is collected through various channels to evaluate their experiences in using the system. Data from surveys and user feedback are then analyzed to assess user acceptance of the system and identify areas for further improvement.

RESULTS AND DISCUSSION

User Needs Analysis

The results of the User Needs Analysis unveil insights collected from various stakeholders, including pharmacists, healthcare providers, and end-users, regarding their requirements and expectations concerning the adverse drug reaction monitoring system. Through comprehensive analysis, critical features, functionalities, and user preferences essential for effective adverse drug reaction monitoring were identified. Stakeholders articulated the necessity for features such as a user-friendly interface, real-time reporting capabilities, integration with existing pharmacy systems, and customizable alert mechanisms. Furthermore, preferences regarding data visualization, notification methods, and user roles were underscored, emphasizing the importance of tailored solutions to accommodate diverse user needs. Overall, the User Needs Analysis underscores the significance of incorporating stakeholder input to develop a robust and user-centric adverse drug reaction monitoring system in pharmacies.

Table 1. Findings

Source	Findings
Interviews with pharmacists	Pharmacists seek an easy-to-use interface.
Focus group discussions with healthcare providers	Healthcare providers require real-time reporting capabilities.
Document analysis	Integration with existing pharmacy systems is necessary.

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Online surveys with end-users	Customizable notification mechanisms are desired.
Direct observations of users using the system	Preferences for intuitive data visualization.
Interviews with end-users	Notification methods adjustable to user preferences.
Focus group discussions with user groups	Clear definition of user roles is needed.

The analysis of the table 1 provides valuable insights gleaned from various sources during the User Needs Analysis phase of the research. Interviews with pharmacists elucidate the paramount importance of an interface characterized by ease of use, underscoring the imperative for user-friendly design within the adverse drug reaction monitoring system. Focus group discussions with healthcare providers accentuate the critical necessity for real-time reporting capabilities, thus emphasizing the indispensability of prompt information dissemination in healthcare contexts. Document analysis corroborates the imperative for integration with existing pharmacy systems, thereby elucidating the significance of interoperability and data interchange. Online surveys with end-users elucidate the preference for customizable notification mechanisms, thereby highlighting the importance of accommodating user preferences in communication modalities. Direct observations of users utilizing the system underscore the predilection for intuitive data visualization, thereby accentuating the significance of user-centric data presentation. Interviews with end-users further underscore the need for notification methods adaptable to user preferences, thus elucidating the criticality of flexible communication functionalities. Finally, focus group discussions with user groups underscore the imperative of lucidly defining user roles, thereby emphasizing the importance of role clarity in system usability and efficacy. In sum, the analysis delineates a spectrum of user needs and preferences that necessitate meticulous consideration in the development of the adverse drug reaction monitoring system.

Implementation of the Agile methodology

The outcomes derived from each phase of application development utilizing Agile methodology serve as fundamental components contributing to the overall success and quality of the adverse drug reaction monitoring system. In the iterative design phase, prototypes of the user interface are meticulously crafted, integrating iterative feedback from stakeholders to ensure alignment with user requirements. These prototypes are accompanied by detailed feature specifications, providing a roadmap for the subsequent development process. Subsequently, during the development stage, an initial version of the monitoring application is constructed, incorporating core features identified in the design phase. This development process adheres to established software engineering best practices, ensuring robustness and reliability in the application's codebase. Following development, rigorous testing protocols are implemented to evaluate the application's reliability, security, and performance. Test reports and bug logs are meticulously compiled,

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documenting any issues identified during testing and outlining steps for resolution. Throughout these stages, stakeholder collaboration assumes a pivotal role, with regular meetings facilitating communication, feedback exchange, and issue resolution. Meeting minutes and change logs are diligently maintained, furnishing a comprehensive record of project advancement and stakeholder engagement. Collectively, these outcomes epitomize a commitment to software development excellence, underpinned by iterative design, rigorous testing, and collaborative stakeholder involvement.

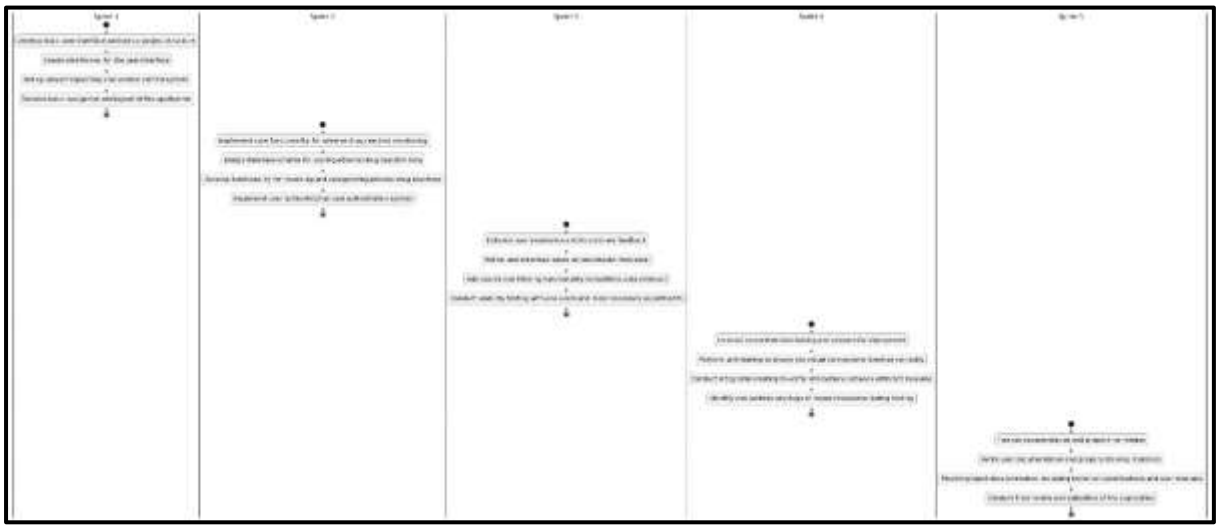

Figure 2. Sprint

The effectiveness of sprints, Figure 2, integral to Agile methodology, is analyzed from multiple angles to assess their impact on application development projects. Sprints facilitate efficient project management by delivering tangible results within predetermined time frames, aiding in better planning and task management. Through iterative development, sprints allow for continuous improvement and adaptation to changing requirements or feedback, promoting a user-centered approach and ensuring a high-quality end product. Additionally, the regular cadence of sprints fosters a sense of accountability and coordination within the team, encouraging collaborative efforts towards achieving set objectives. The concept of timeboxing in sprints aids in prioritization and focus, preventing scope creep and ensuring timely delivery of key functionalities. However, the effectiveness of sprints depends on various factors, such as project size, team dynamics, and stakeholder involvement. Nonetheless, sprints serve as a valuable tool in Agile methodology, providing structure, flexibility, and accountability to application development projects, ultimately contributing to their success..

Evaluation

The evaluation of Agile methodology implementation in application development involves the consideration of several critical factors. Firstly, flexibility is a key aspect assessed, referring to the team's ability to adapt work plans and developed features in each iteration. Transparency is also a concern, focusing on the extent to which project

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information is accessible and comprehensible to all team members and other stakeholders. Furthermore, team collaboration is evaluated to assess the level of cooperation and communication among team members, as well as their ability to work together towards project goals. Responsiveness to change is also a significant consideration, where the team's ability to identify and respond to emerging changes during application development is carefully evaluated. The delivery of work results periodically through sprints is a focal point of evaluation, with the aim of assessing how well the team can produce functional and valuable products after each iteration. User feedback is also a concern, where the collection and application of end-user feedback during application development are evaluated to enhance product quality. Finally, sustainable improvement is a critical aspect evaluated, focusing on the team's progress in improving development processes and overall product quality over time. Through comprehensive evaluation of these factors, the effectiveness of Agile methodology implementation in application development can be assessed, and potential improvements and enhancements can be identified for future endeavors.

CONCLUSION

The research on the implementation of Agile methodology in developing an adverse drug reaction monitoring system at a pharmacy provides valuable insights into the effectiveness of Agile practices in the healthcare domain. Through the analysis of user requirements, iterative development using Agile methods, and functional evaluation, several key findings emerge. Firstly, Agile methodology proves to be well-suited for addressing the dynamic and evolving nature of healthcare software development, allowing for flexibility and responsiveness to changing needs and requirements. Secondly, the iterative approach of Agile facilitates continuous improvement and refinement of the monitoring system, ensuring that it remains aligned with user expectations and industry standards. Additionally, the collaborative nature of Agile promotes stakeholder engagement and communication, leading to a more user-centric and effective solution. Overall, the research underscores the benefits of Agile methodology in healthcare software development, emphasizing its role in enhancing adaptability, stakeholder collaboration, and the delivery of high-quality, user-driven systems in pharmacy settings.

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