

Artificial Intelligence for Adaptive Planning of Healthcare Projects

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Abstract: Planning and managing healthcare projects involves making decisions in conditions of high uncertainty due to a complex and turbulent environment, technological transformation, and the use of largely subjective resources of tacit knowledge possessed by project managers as a result of accumulated years of experience. It is desirable to look for solutions that allow for the creation of flexible and agile systems supporting the management of updated knowledge resources, enabling dynamic adaptation to current problems and changing environmental conditions. One possible solution is using intelligent systems that would support adaptive planning. The paper aims to present an AI model for knowledge management in adaptive planning of healthcare projects, which are usually complex, expensive, and require efficiently updated interdisciplinary scientific knowledge. Additionally, such projects often only have generally formulated goals and planned results, which makes their definition, planning, and initial evaluation much more difficult. Thanks to the conclusions drawn from this research, it is possible to reduce the number of errors made during project planning, which usually significantly affect the implementation and success of projects. It is justified to develop interdisciplinary research conducted on the border of healthcare project planning and AI computing systems because expert planning methods dominate, and there is a lack of adequate support. Implementing this type of research and its further continuation allows for the creation of knowledge and methodological solutions related to introducing AI computation to healthcare projects to assist agile decision-making.

Keywords: Artificial intelligence, Healthcare project management, Adaptive planning methodology, Knowledge management

1. Introduction

In the scientific literature on healthcare projects, there are relatively few studies on the problems of planning, project management, and supporting the related processes with AI models that facilitate knowledge management. The attention of many authors is focused primarily on medical issues, e.g., those related to deep learning-assisted surgical systems (Kaleta *et al.*, 2023). In addition, there is a paucity of research on the importance of AI in creating adaptive and agile approaches useful for developing knowledge management models in healthcare project planning. It is worth filling this research gap, because following an Agile mindset is usually associated with achieving significant benefits that are qualitatively and quantitatively measurable.

When Agile Methodology and Agile Mindset principles are applied by teams during the planning and implementation of activities, it is possible to conduct healthcare projects adaptively and flexibly and achieve measurable benefits. These principles include procedures that strengthen flexible cooperation in interdisciplinary project teams operating in healthcare institutions, knowledge management, and learning that enables adaptation to internal and external changes to achieve high-performing results that meet the needs of diverse stakeholder groups. Knowledge about Agile Mindset is considered to be in its early stages of development, because there is a lack of research related to the conceptualization of this concept, and it occurs mainly in a tacit form, i.e., related to experts and project managers. Using this knowledge is associated with adopting an attitude that supports strengthening cooperation, empowered self-guidance, learning, knowledge management and customer co-creation in the conditions of the VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) environment (Eilers *et al.*, 2022).

The implementation of Agile principles, adaptive planning, iterative development and continuous improvement in a turbulent project environment can be particularly useful in managing healthcare projects in a situation where dynamic technological transformations in healthcare, frequent changes in legal regulations, European Union guidelines and growing requirements for patient care can be noted (Cordero, 2023). Agile mindset and adaptive planning principles are particularly desirable for healthcare projects, because they are usually very complex and expensive, have only broadly outlined goals and planned outcomes, and require rapidly updated, sophisticated, interdisciplinary scientific knowledge. There is a lack of research on AI-driven support for adaptive planning through tacit knowledge management, i.e., knowledge related mainly to healthcare project management experts.

The paper aims to present an AI model for knowledge management in adaptive planning of healthcare projects, which are usually complex, expensive, and require efficiently updated interdisciplinary scientific knowledge.

Undertaking this type of research is important because it creates a basis and directs further research processes related to proposing solutions related to introducing AI models to support decision-making processes in healthcare projects. The results of research related to intelligent decision support systems can help improve the quality of healthcare projects, reduce the number of errors made during project planning, improve their implementation, and increase the probability of achieving success measured by the satisfaction of diverse stakeholder groups.

2. The Essence of Adaptive Planning and Management in Healthcare

Adaptation can be understood as a way of shaping the future through the ability of an organization to make ethical decisions and actions regarding rapid and effective adjustment to changing environmental conditions by consciously implementing changes that take into account the well-being of important stakeholders (Krajcsák and Bakacsi, 2024). Adaptation is related to the management of changes, the effective implementation of which is difficult, e.g., as a result of the lack of leaders responsible for change management, inappropriate organizational culture, implementation of fragmented change management only at some levels, resistance to change, insufficient employee involvement, poor communication and improper integration of change management with other complementary approaches (Bassi and Shinde, 2024). Change management requires using appropriate adaptive methodologies, implementing continuous project monitoring processes, and a flexible response to situations described based on the values of monitoring indicators. A flexible approach to planning and implementing healthcare projects allows drawing conclusions that direct adaptive changes to the implemented activities (Van Assche *et al.*, 2023).

In the conditions of a turbulent environment and high uncertainty usually accompanying healthcare projects, adaptive planning based on iterative processes and agile approaches is therefore useful. By these approaches, a way of thinking is adopted that assumes moving away from rigid schedules and unchanging project documentation, in favor of introducing flexible and dynamic principles of adapting to changing circumstances. It is assumed that the rich scientific achievements related to the development of innovative business models and the concept of adaptation, which is known from the theory of strategic management, are used. The theory of organizational adaptation helps understand the possibilities of increasing an organization's chances to survive and achieve success through its ability to adapt to changing environmental conditions (Sarta *et al.*, 2021). There is a growing interest in the scientific community in conducting research related to the issues of adaptability of organizations and increasing resistance to external factors in connection with the occurrence of multi-faceted and diverse processes of globalization, technological evolution, growing shortage of available resources and increasing requirements of stakeholders (Yin, 2023).

The research results indicate a positive impact of replacing traditional project management methodologies with agile methodologies. This positive impact is manifested by improving the efficiency of project teams, increasing the ability to manage knowledge effectively, improving the interdisciplinary skills of team members and the ability to adaptively adjust to changing environmental conditions (Ciric Lalic *et al.*, 2022). Agile methodologies enable the introduction of useful adaptive solutions, the first successful implementations of which are known from successfully completed IT projects (Binboga and Altin Gumussoy, 2024). More and more bold attempts are being made to use these experiences for various types of projects with significant innovation, complexity, and uncertainty regarding the obtained multidimensional results, e.g., clinical trials and various projects implemented in healthcare. Digital health evolution, which implies the healthcare sector's transformative dynamics, requires understanding the essence of the value-based healthcare context and developing forward-looking research on innovative approaches and models of adaptive management of healthcare projects to achieve better outcomes (Vesty, 2024).

The use of models for adaptive planning is justified for healthcare projects because they are often implemented sequentially in long and expensive processes. Adaptive approaches enable the introduction of principles of flexibility in combining and implementing individual phases of these processes. This usually entails a significant reduction in the planning and implementation time of complex projects, simplifying planning processes of interconnected stages, and also enables substantial savings and a reduction in the size of the research sample for clinical research projects (Ma *et al.*, 2022).

Interesting and inspiring research on models for adaptive planning of healthcare projects concerns the possibility of using metaheuristic algorithms and AI methods. Such models are suitable for complex healthcare projects (e.g., related to clinical trials), which are characterized by multi-faceted dependencies that are difficult to analyze using traditional approaches (Zhu and Wong, 2023).

3. AI for Knowledge Management and Adaptive Planning of Healthcare Projects

The field of healthcare project management is constantly changing due to groundbreaking AI technologies and the dynamic development of data-driven project management. This development contributes to the emergence of challenges that project managers have to cope with. Currently, it is necessary to develop digital competencies of data-driven project managers, who are required to conduct analyses of diverse and uncertain empirical data to support making sometimes difficult decisions regarding improving projects towards ensuring long-term benefits. AI approaches, methods, and tools can contribute to improving the quality and effectiveness of the processes of adaptive planning, evaluation, and implementation of projects. Significant potential lies, for example, in mixed AI systems, which are based on integrating quantitative and qualitative methods, allowing for the analysis of complex and interdisciplinary projects with very different evaluation criteria (Grzeszczyk, 2018). In turn, basing on the systems approach and drawing inspiration from new achievements in generative AI and selected mathematical models (e.g., based on generalizations of rough sets theory useful in multicriteria decision analysis processes) allows for building knowledge systems supporting project evaluations (Grzeszczyk, 2024).

AI methods are also useful for building knowledge bases for pharmaceutical and medical device industry experts and implementing mechanisms to support the evaluation of pharmaceutical formulations and drug development processes (Bhupathyraaj *et al.*, 2023). Such constantly updated knowledge bases can be used by knowledge workers focused on using non-routine cognitive processes and innovative tools for analysis, evaluation, and idea generation, which may be useful in a specific situation of research processes in healthcare. The search for new decision support instruments in the field of clinical trials is of great importance because drug development is very expensive and time-consuming, and is often associated with a large number of failed research projects. AI can play a multi-faceted role in drug development projects and modernizing support systems for efficient drug delivery (Visan and Negut, 2024).

AI and knowledge management are fields related to learning and using knowledge. AI is generally based on learning and building knowledge bases, while building knowledge management systems allows for a better understanding of the usefulness of knowledge (Pai *et al.*, 2022). AI enables effective support for project planning and implementation in conditions of uncertainty, insufficient knowledge resources, and unpredictable events that require adaptation of originally assumed plans and schedules. Intelligent systems that enable dynamic and adaptive adjustment of project schedules in response to disruptions related to resource availability and problems with their substitutability are particularly useful in practice (Xu and Bai, 2024).

AI models are increasingly used in medical processes, diagnostics, medical data analysis, image recognition, e.g. from computed tomography, discovery and development of new drugs. However, there is still little significant research on management issues related to supporting the planning, management, and evaluation of healthcare projects using AI and intelligent adaptive methods. Providing this type of methodological support, especially at the planning stage and making *ex ante* assessments, is justified due to the complexity of many healthcare projects, which also require significant costs for their implementation. The lack of appropriate AI tools for knowledge management and adaptive planning of healthcare projects can contribute to errors during planning, which usually significantly affect the later implementation and success of the projects.

Adaptive planning of healthcare projects using AI models is helpful in the context of decision-making in conditions of high uncertainty resulting from a changing environment, technological transformation, and the use of largely subjective resources of tacit knowledge possessed by project managers as a result of many years of accumulated experience. AI can support the processes of improving the management of healthcare projects by providing a flexible approach to improving planning and decision-making, adapted to current problems.

AI models can support data analysis, knowledge discovery from empirical data, and predictive analytics. AI's usefulness comes from its ability to process vast amounts of diverse empirical data from various sources (e.g., patient records, clinical trials, medical studies). AI methods are used to identify patterns in data, support knowledge management, and predict project outcomes. Project managers can have this type of support in making decisions about the effective allocation of resources, even in conditions of significant risk and uncertainty. Decision support is the basic task of AI systems for knowledge management. This support is based on recommendations prepared using usually huge sets of historical data, best practices, and real-time analyses. The use of complex AI algorithms is especially useful in complex scenarios for which many variables must be considered.

AI can also support personalization, customization, and adaptation of project management strategies to the specific needs of different healthcare facilities, patient populations, and their changing needs. Adaptive

algorithms can keep up with these changes and facilitate adjustments to plans based on real-time data. This can ensure responsiveness to changing circumstances in the project environment. AI and knowledge management tools can facilitate communication, strengthen collaboration, and engagement among project stakeholders, including providers, patients, and administrators.

Typical AI applications also include automation of routine tasks, such as planning, scheduling, resource allocation, and progress tracking. Such AI models for expert knowledge management can help reduce the administrative burden on project managers and allow them to focus on more substantive and strategic activities.

Adaptive approaches, agile project planning and knowledge management systems are helpful in supporting real-time adjustments, continuous monitoring of project progress and external factors. The results of monitoring processes can facilitate flexible adjustments of project plans and schedules in real time and in an iterative manner. Additionally, AI models can support the generation and evaluation of multiple project scenarios useful for project managers who need to respond to unexpected and rapid changes in the project environment.

Support in tacit knowledge management can be primarily knowledge bases, domain knowledge repositories and knowledge-based systems. Knowledge bases usually enable rapid updating of interdisciplinary knowledge. AI-based knowledge repositories can be used to collect and store valuable experiences and conclusions resulting from previous projects. This allows for the provision of continuous learning mechanisms and continuous improvement of project management practices by using the growing collective expertise. AI systems can continuously collect and facilitate the implementation of current research results, clinical guidelines and scientific discoveries. Thanks to this, the knowledge bases being built remain constantly up-to-date and comprehensive, allowing for the inclusion of the latest achievements in healthcare projects.

Expert and knowledge-based systems enable the capture and codification of interdisciplinary tacit knowledge of experts and knowledge workers. These systems can be used to collect and process knowledge from experienced project managers, which can then be used to support less experienced project managers to ensure continuity and consistency in decision-making processes. Knowledge-based systems can support decision-making processes and have important implications for knowledge management. These implications include facilitating cooperation between project team members representing different knowledge areas and providing a comprehensive approach to supporting the management of complex projects requiring input from different knowledge areas. Efficient knowledge management, adapting knowledge bases to changing situations, can help identify emerging threats and effectively manage risk. Expert systems can suggest possible solutions based on current knowledge and create conditions for project managers to proactively adjust the implementation strategy of individual projects and entire programs implemented in healthcare. This is especially important in the case of many high-risk projects, the failure of which can affect programs (sets of projects) and the functioning of entire organizations. Using (timely) updated knowledge bases can significantly impact the likelihood of success in undertaken project activities.

The use of AI models for knowledge management and adaptive planning of healthcare projects increases the possibilities of using current knowledge systems, flexible response to the variability of the environment and effectiveness of achieving success. The combined use of agile methodologies, tacit knowledge management and ongoing updating of interdisciplinary knowledge based on AI enables the creation of a friendly environment in which healthcare projects can be successfully planned and implemented despite their complexity and significant uncertainty.

4. Methodology

The research process was carried out in two stages: analysis of the subject literature and developing an AI model for adaptive planning of healthcare projects. During the research carried out in the first stage, the Scopus database and keywords belonging to the following five concept areas were used: 'AI models', 'adaptive planning methodologies', 'project management', 'healthcare systems', and 'decision-making'. The results of the literature research formed the basis for conducting a usability analysis of the adaptive approach, as well as a review of the possibilities of using available AI models for flexible and knowledge-based support of planned projects. The results of this usability analysis provided opportunities for finding and using AI systems in the model being built, which would support knowledge management useful in effective project planning. This allowed for defining the goal, which is to develop an AI model for adaptive planning of healthcare projects, which are usually complex, expensive, and require efficiently updated interdisciplinary scientific knowledge. The specific research goal directed the research process towards a preliminary analysis of AI-driven knowledge management models in terms of their usefulness in adaptive project planning in healthcare. The following research methods were used

to help conduct the planned theoretical analyses and in the empirical research process of the AI model for adaptive planning: literature review, direct observation of healthcare project planning processes, document analysis, modeling, and computer simulations.

The development of the model is based on a process approach to knowledge management, according to which the following processes can be distinguished: knowledge acquisition (extracting, structuring, and organizing knowledge), knowledge dissemination and knowledge application. Knowledge acquisition, its discovery, and improvement are carried out with the support of AI technology and knowledge-based systems. Dissemination of knowledge also mainly concerns specialized high-level knowledge obtained through the use of such technological solutions. Knowledge application means transforming discovered knowledge into decisions related to the continuous improvement of planned projects. Implementing the aforementioned knowledge management processes is crucial for organizations' success in innovative and design activities (Yusr *et al.*, 2017).

In the computer modeling and simulation processes, a rule-based system was used, which allows for the reflection of interdisciplinary achievements useful in supporting knowledge management. Knowledge-based systems are often performed using rules, which are one of the most important forms of knowledge discovered on the basis of empirical data. Many data and rule-based systems are useful for discovering new and potentially useful patterns, which are a desirable and understandable form of knowledge useful in adaptive project planning. In general, empirical data processing and knowledge discovery is carried out as a result of repeating the following stages: collecting and updating data, preprocessing, exploration of data, postprocessing, updating the knowledge base, improving the obtained results by knowledge engineers and experts, using the discovered knowledge in processes related to project planning. Drawing conclusions for a given iteration loop helps implement the principle of continuous learning and improvement. Preprocessing concerns preparing collected empirical data for the selected algorithm to determine patterns and knowledge. The Apriori algorithm for discovering association rules accessible in TIBCO Statistica 13.3 software was used in the computer modeling and simulation process. Postprocessing results support work on the form of knowledge that can be practically used. The above-mentioned stages create a feedback loop, within which the current data set and the current form of knowledge are applied. They are updated for the next iteration.

The chosen symbolic form of knowledge representation offers advantages over deep learning approaches based on neural networks. While deep learning models often produce complex, spatially distributed knowledge representations that are difficult for experts to interpret, symbolic methods generate structured, human-readable outputs. The selected approach facilitates the processing of diverse data, supports knowledge discovery, and enables the construction of interpretable patterns. Rule-based systems are particularly well suited for adaptive planning processes due to their clear and intuitive structure, typically expressed as: "If antecedent, then consequent." This conditional format effectively captures the relationships identified through empirical data analysis. Such rules often represent meaningful and non-trivial associations between variables within large datasets, making them both practically relevant and applicable. Moreover, generating symbolic knowledge using rule-based models is relatively straightforward. These models are especially valuable in the context of the rapidly expanding volume of information and knowledge associated with modern healthcare project planning and implementation. They offer robust support for analyzing empirical data, which is frequently ambiguous or imprecise, and can enhance decision-making by providing transparent, interpretable insights.

5. Results and Discussion

During the development of the model, it was assumed that the principles specific to adaptive planning processes and empirical data processing and knowledge discovery regarding rule-based systems, which were specified in the Methodology section of this paper, would be considered. Therefore, the first stage is the situation assessment and data gathering (Figure 1). This stage concerns the analysis and assessment of the project environment, operating conditions, and the needs met that are important for the local community and various groups of its stakeholders. The next two stages are related to preparing and implementing the knowledge discovery process using the rule-based system. The post-processing stage is necessary to organize the imprecise form of knowledge obtained after the application of the algorithm for inducing rules and ensures filtering of rules, as well as integration of knowledge to ensure its coherence.

The fourth stage is related to knowledge base extension and an alternative learning paradigm (Never-ending learning), which assumes that the system learns incrementally and continuously (Mitchell *et al.*, 2018). In the developed model, this paradigm is used for continuous iterative learning, modification of the knowledge base,

and adaptation of knowledge to current and changing situations concerning planned projects. After modification of the knowledge base, it is necessary to conduct its evaluation and ongoing improvement (stage five).

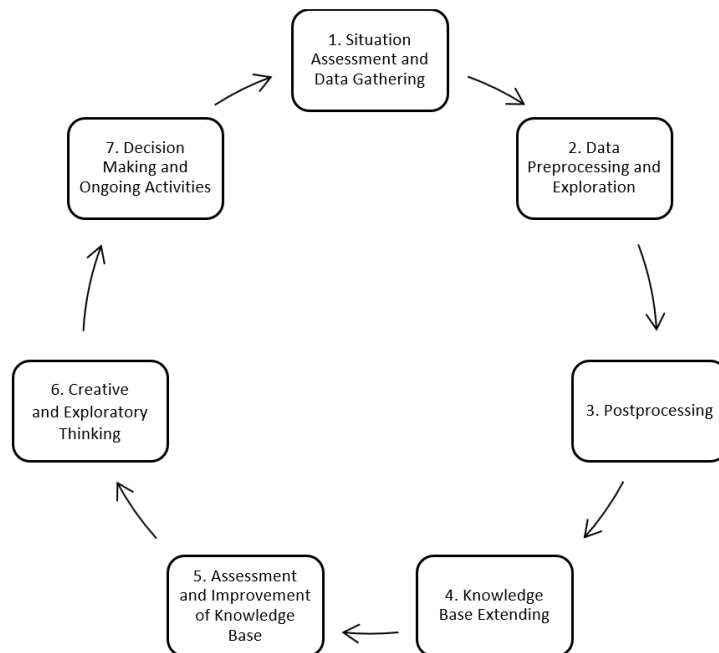


Figure 1: AI model for knowledge management in adaptive planning of healthcare projects (source: Own study)

In accordance with the idea of the adaptive approach, current decisions are made after considering strategic priorities (stages 6 and 7). Short-term plans and implementation of current activities should be consistent with the strategic management of projects and programs. In the case of complex projects in healthcare, in the face of significant uncertainty, technological transformations, and changing requirements, it is necessary to include exploratory thinking in the planning processes. There are positive experiences related to building innovative planning perspectives and the potential for alternative approaches to long-term planning in the provision of public services using planning interventions based on exploratory thinking (Malekpour *et al.*, 2016). Adaptive approach and change management aimed at ensuring lasting changes and effectiveness in the strategic approach to project success is one of the most important trends in healthcare project management. Research confirms the importance of strategic project and portfolio management in healthcare, which should be supported by organizations, e.g., as a result of launching a dedicated office equipped with appropriate decision support tools (Cristina *et al.*, 2024).

A significant advantage of the proposed model is its universality and practical usefulness for using a variety of empirical data that may come from interviews, project stakeholder surveys, and project documentation. The adopted iterative nature of the model enables the implementation of the principles of adaptive and agile planning. Individual cycles can be repeated many times, and the improved knowledge base can be used. The proposed solution, based on the AI model and knowledge management for adaptive planning of healthcare projects, is characterized by significant flexibility and scalability. This ensures the possibility of further model development and significant application potential.

6. Conclusions

This study addresses a critical challenge in healthcare: improving adaptive planning methods for complex and costly projects under conditions of high uncertainty. Project decisions—especially short-term ones—often carry long-term strategic consequences and must account for rapid environmental changes and ongoing technological transformation in healthcare institutions. AI models offer valuable support for such decision-making by enabling the analysis of diverse, large-scale datasets and integrating various types of knowledge.

A key challenge lies in incorporating tacit, subjective knowledge held by domain experts, project managers, and team members. This highlights the need for advanced AI-based models capable of continuous learning and dynamic adaptation, supported by ever-evolving, interdisciplinary knowledge bases. Such models can

significantly enhance adaptive planning by enabling real-time data mining, knowledge discovery, and knowledge management in intelligent adaptive systems.

The research supports the development of interdisciplinary studies at the intersection of project management and AI. While much existing AI research focuses on clinical applications and decision support for healthcare professionals, there remains a clear gap in applying AI and ICT tools to healthcare project and program management. Strengthening this area within management sciences is both timely and necessary.

The achievement of the research objective lays a foundation for advancing adaptive planning in healthcare through AI. Particularly promising are avenues exploring innovative planning paradigms, such as incorporating exploratory thinking and generative AI techniques. These can enhance strategic change management and contribute to long-term project success.

Future research should focus on refining these models and tools, with special attention to generative AI as a means of improving adaptability and innovation in planning processes. This approach holds strong potential for fostering more resilient, knowledge-driven project environments in the healthcare sector.

Acknowledgements

This study was supported by the EU's Horizon 2020 programme (grant no. 857533, Sano) and the Foundation for Polish Science's International Research Agendas programme, co-financed by the EU under the European Regional Development Fund and the Polish Ministry of Science and Higher Education (contract no. MEiN/2023/DIR/3796). Sano Centre for Computational Medicine, Health Informatic Group Team, Czarnowiejska 36/C5, 30-054 Krakow, Poland (<https://sano.science/>).

Ethics declaration: Ethical clearance is not required for this research.

AI declaration: AI tools were used in the computer modeling and simulation processes described in this paper.

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