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Development of Uni-HEALS: Semantic Search and Forecasting-Enhanced University Health Care Management System

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Abstract *— This study presents the development of Uni-HEALS: a Semantic Search and Forecasting-Enhanced University Health Care Management System aimed at improving efficiency, accessibility, and decision-making in university health services. Conventional health care systems in academic institutions often suffer from fragmented records, limited retrieval capabilities, and the absence of predictive analytics for service planning. To address these challenges, UNI-HEALS was designed and developed using the Agile methodology and evaluated during a pilot deployment at NEUST University's health clinic – Sumacab Campus - to define the study's scope and operational context clearly. IT experts assessed system quality and end users using the ISO/IEC 25010 Software Product Quality Model, and end users also evaluated the system's acceptability. Quantitative results revealed that IT experts rated the system with a grand mean of 3.59, verbally interpreted as an Excellent Quality System, indicating that Uni-HEALS meets and exceeds the required software quality standards. End-users similarly assessed the system with a grand mean of 3.64, indicating Excellent Quality and high satisfaction with performance, effectiveness, and ease of use. Moreover, the system's acceptability had an overall mean of 3.70, interpreted as Highly Acceptable, demonstrating that Uni-HEALS met all acceptability criteria and showed no significant weaknesses during implementation. In addition to performance metrics, a comprehensive cost-benefit analysis was conducted to evaluate the feasibility of system deployment, including hardware and software. These findings confirm that the system consistently satisfied both technical and user requirements, supporting its viability for enhancing health care management and decision support in university clinic environments and contributing to innovative campus health system initiatives and practicality.*

Keywords *— **University Health Care Management, Semantic Search, Forecasting Analytics, Agile Methodology, ISO/IEC 25010, Smart Campus System***

I. INTRODUCTION

In recent years, the increasing complexity of healthcare management within universities has created an urgent need for smarter, faster, and more data-driven systems. University clinics today serve thousands of students, faculty, and staff requiring accurate medical records, efficient patient flow, and timely decision-making to support campus health and safety World Health Organization [WHO], 2020).[1] However, many schools, including the Nueva Ecija University of Science and Technology (NEUST), continue to rely on manual or semi-digital processes that create delays, inconsistencies, and operational bottlenecks.

At NEUST, several challenges impair the daily operation of the University Clinic/Infirmary. Patient records remain scattered across paper forms, logbooks, and partially digitized files, leading to slow

retrieval, redundant entries, and risks of misplacement. Consultation requests and student visits often surge during examination weeks, cold seasons, or unexpected outbreaks. However, the clinic cannot anticipate these increases because there is no forecasting tool for patient influx or medicine demand. Medicine inventory is also monitored manually, leading to delayed replenishment, expired stock, and reactive procurement. These issues collectively reduce efficiency, increase waiting times, and limit the clinic's ability to provide timely care and make informed decisions.

These operational barriers reflect the broader challenges schools nationwide face. Academic institutions typically manage large student populations with limited medical staff, leading to a heavy reliance on accurate records, well-organized scheduling, and reliable health information systems. Schools commonly encounter problems such as data duplication, delayed access to medical histories, lack of centralized reporting, inconsistent documentation procedures, and difficulty predicting seasonal illness trends (Alshamari et al., 2021). [2] Without intelligent tools, university clinics operate reactively rather than proactively, responding only when shortages, surges, or emergencies already occur.

One of the most critical gaps is the absence of an intelligent medical information retrieval system. Traditional search functions depend on exact keywords, making it challenging to locate patient information when spelling varies, symptoms overlap, or medical terms differ. (Hliaoutakis et al., 2006; Guha et al., 2016). [3] Uni-Heals Semantic search addresses this problem by understanding the meaning and relationships between concepts, enabling context-aware retrieval of clinical information (Ristoski & Paulheim, 2016; Lin & Chen, 2019).[4] For NEUST, this means faster, more accurate access to patient histories, diagnoses, and medicine usage, directly addressing current retrieval delays.

Another significant gap involves the lack of predictive capabilities. Schools often experience sudden spikes in consultations during flu season, weather changes, examination stress periods, and campus events. Uni-Heals Forecasting tools can analyze historical clinical data to predict patient volume, medicine consumption, seasonal illness patterns, and staffing needs (Li et al., 2022). [5] For NEUST, forecasting directly addresses two significant problems: slow, reactive resource planning and unpredictable patient congestion. Forecasting enables proactive stocking and preparation, anticipates peak periods, and supports smoother scheduling.

Given these gaps, the development of Uni-HEALS: Semantic Search and Forecasting - Enhanced University Health Care Management System, is proposed to transform NEUST's clinic into a modern, intelligent, and proactive health service unit. The system integrates centralized medical records, semantic search for intelligent information retrieval using Natural Language Processing (NLP), and forecasting analytics using Linear Regression for health trend prediction, and automated processes for clinic operations, service demand, and resource utilization.

Ultimately, by implementing Uni-HEALS, NEUST can advance its institutional commitment to innovation, operational excellence, and student welfare. Moreover, it positions the university at the forefront of digital transformation in campus healthcare systems. As academic institutions increasingly adopt digital health management solutions, the proposed system may serve as a model for other universities seeking to modernize their healthcare services with intelligent, data-driven, and sustainable features. This aligns with the United Nations Sustainable Development Goal 3 (Good Health and Well-Being), which emphasizes the importance of technology-driven healthcare innovations in promoting wellness and ensuring access to quality health services for all (United Nations, 2023).[6]

It is specifically intended to: Develop and evaluate the Uni-HEALS: Semantic Search and Forecasting–Enhanced University Health Care Management System using a Modified Agile Development Life Cycle comprising planning, design, development, testing, deployment, and maintenance. System quality was assessed by IT experts using the ISO/IEC 25010 Software Product Quality Model, covering functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. End-users evaluated the system based on selected ISO/IEC 25010 criteria: functional suitability, performance efficiency, and usability; and further assessed its level

of acceptability to determine its suitability for implementation in a university clinic setting.

II. METHODOLOGY

This study adopted a mixed-method research design integrating developmental and descriptive–evaluative approaches to develop and assess the Uni-HEALS: Semantic Search and Forecasting–Enhanced University Health Care Management System.[7] System development followed the Agile Software Development Life Cycle, enabling iterative design, implementation, and refinement based on user feedback.[8] The study was conducted at the Nueva Ecija University of Science and Technology (NEUST) University Clinic/Infirmary in Sumacab Campus, Cabanatuan City, Nueva Ecija, Philippines. Data were collected from purposively selected IT experts (10) and five (5) end-users through structured questionnaires, interviews, and system testing to evaluate both technical and functional performance using the ISO/IEC 25010 Software Product Quality Standards.[9]

Data analysis employed weighted mean statistics based on a four-point Likert scale to determine system compliance and acceptability, with an acceptance threshold of 2.50. Qualitative data supported system validation and refinement. The study was anchored on the ISO/IEC 25010 Quality Model and the Agile Development Framework, organized through an Input–Process–Output (IPO) conceptual framework. Inputs included system requirements and resources; processes involved agile development and evaluation; and outputs consisted of a validated, user-centered, and standards-compliant healthcare management system tailored to NEUST clinic operations.

III. RESULTS AND DISCUSSION

This study presents the development of the Uni-HEALS: Semantic Search and Forecasting–Enhanced University Health Care Management System, following the Agile Development Life Cycle, with iterative phases of planning, design, development, testing, deployment, and maintenance to ensure adaptability, stakeholder collaboration, and continuous refinement. During the planning phase, system requirements were identified through consultations and focus group discussions with university clinic personnel, addressing challenges in manual record handling, data security, and decision support. These inputs defined the project scope, functional and non-functional requirements, and guided sprint planning. The design phase translated these requirements into concrete outputs, including use case diagrams, data flow diagrams, and an entity–relationship model that structured system workflows, database relationships, and user roles. These design artifacts served as the blueprint for system construction, ensuring alignment with clinic operations and data governance standards.

In the development phase, the system was incrementally built through iterative sprints, resulting in core modules such as electronic health records, semantic search powered by Natural Language Processing, forecasting of health trends and medical supplies using Linear Regression, and role-based access control for security. Testing and evaluation were conducted continuously across unit, integration, system, and user acceptance testing, involving both IT experts and end users to validate functionality, usability, performance, and security. The deployment phase involved a pilot implementation in the university clinic, where the system was installed, configured, and evaluated in a controlled operational environment without disrupting clinic services. Finally, maintenance was addressed through a structured plan that included regular monitoring, bug fixes, security reviews, database optimization, and periodic updates to ensure sustained performance, reliability, and scalability. Collectively, these phases demonstrate that the Agile approach effectively supported the successful development, evaluation, and pilot deployment of Uni-HEALS within a real-world university healthcare setting.

The following are the summarized results of the IT Experts system evaluation based on the Software Product Quality Standards, which outline eight primary criteria: functional suitability, performance efficiency, usability, reliability, maintainability, compatibility, security, and portability; and for End-users are the following: functional suitability, performance efficiency, usability. Also, the End-users' acceptability rating of the Uni-HEALS data for each is presented below.

Table 1. Summary of the IT Experts' Evaluation of Uni-HEALS: Semantic Search and Forecasting-Enhanced University Health Care Management System

Uni-HEALS: Semantic Search and Forecasting-Enhanced University Health Care Management System	Overall Mean	Descriptors
Functional Suitability	3.60	Highly Functional
Performance Efficiency	**3.73**	**Highly Efficient**
Compatibility	3.35	Highly Compatible
Usability	**3.75**	**Highly Usable**
Reliability	3.43	Highly Reliable
Security	**3.78**	**Highly Secured**
Maintainability	3.58	Highly Maintainable
Portability	3.53	Highly Portable
Grand Mean	**3.59**	**Excellent Quality System**

Source/s: IT Experts' Evaluation Tool based on the ISO 25010 Software Product Quality Standards

Table 1 summarizes the IT experts' evaluation of the Uni-HEALS: Semantic Search and Forecasting–Enhanced University Health Care Management System across eight ISO/IEC 25010 quality attributes. The system achieved its highest rating in Security (M = 3.78, Highly Secured), reflecting the effective implementation of role-based access control, data encryption, and secure storage—features critical for protecting sensitive health information in university clinic environments. Compatibility obtained the lowest mean (M = 3.35, Highly Compatible), indicating generally effective system integration with minor opportunities for enhanced interoperability. Overall, Uni-HEALS attained a grand mean of 3.59, indicating an Excellent Quality System and demonstrating compliance with and exceeding software quality standards.

The high scores for Security (M = 3.78), Usability (M = 3.75), and Performance Efficiency (M = 3.73) are consistent with findings from related healthcare information system studies. Prior research highlights that RBAC and encryption significantly strengthen system security and user trust (Wager et al., 2017) [10], while semantic search and NLP-based interfaces improve usability and user satisfaction (Petter et al., 2008) [11]. Moreover, integrating forecasting and predictive analytics supports efficient data processing and informed decision-making, aligning with established evidence on the benefits of analytics-driven healthcare systems (DeLone & McLean, 2003) [12]. Compared with conventional university health systems focused mainly on record digitization, Uni-HEALS delivers greater value through intelligent retrieval and forecasting capabilities, reinforcing its role as a secure, efficient, and user-centered healthcare management solution.

Table 2. Summary of the End-Users' Evaluation of Uni-HEALS: Semantic Search and Forecasting-Enhanced University Health Care Management System

Uni-HEALS: Semantic Search and Forecasting-Enhanced University Health Care Management System	Overall Mean	Descriptors
Functional Suitability	**3.67**	**Highly Functional**
Performance Efficiency	3.60	Highly Efficient
Usability	**3.67**	**Highly Usable**
Grand Mean	**3.64**	**Excellent Quality System**

Source/s: End Users' Evaluation Tool based on the ISO 25010 Software Product Quality Standards

Table 2 presents the summary of the End-Users' evaluation of the Uni-HEALS: Semantic Search and Forecasting–Enhanced University Health Care Management System across selected ISO/IEC 25010 quality attributes. The high end-user ratings for Functional Suitability (M = 3.67) and Usability (M = 3.67) can be linked to the system's alignment with users' workflows and its intuitive interface design. The semantic search module facilitated natural language–based retrieval of patient data, reducing cognitive load and task complexity, factors shown in prior research to improve user satisfaction and perceived usefulness in healthcare information systems (HIS) implementations (Dehghani Mahmoodabadi et al., 2025) [13]. Furthermore, the integration of forecasting analytics supported timely planning and reporting, enhancing functional relevance and operational effectiveness, a pattern echoed in studies identifying predictive and decision-support features as key drivers of user satisfaction and system efficiency in health IT adoption (Nature Communications, 2024) [14]. Comparative literature also underscores that usability and efficiency are among the most frequently evaluated and highly valued criteria in HIS studies, with systematic reviews highlighting their strong influence on user acceptance and workflow integration (Dehghani Mahmoodabadi et al., 2025) [15].

Table 3. End-Users' Evaluation of the Acceptability of Uni-HEALS: Semantic Search and Forecasting-Enhanced University Health Care Management System

Acceptability	Mean	Descriptors
Uni-HEALS provides accurate and reliable semantic search and forecasting for the NEUST University Clinic/Infirmary.	3.40	Highly Acceptable
The interface of Uni-HEALS is user-friendly and easy to navigate for the end user.	3.80	Highly Acceptable
Uni-HEALS efficiently provides real-time updates and status monitoring of health records.	3.60	Highly Acceptable
Uni-HEALS is accessible and usable by different types of users.	**4.00**	**Highly Acceptable**
Uni-HEALS responds quickly to user actions and provides timely feedback on health records/status.	3.60	Highly Acceptable
Uni-HEALS contributes to sustainable and well-structured health record management within the university clinic.	3.60	Highly Acceptable
Uni-HEALS is stable and operates smoothly without frequent system errors or crashes.	3.60	Highly Acceptable
Uni-HEALS integrates effectively with NEUST's existing infrastructure, databases, and workflow processes.	**4.00**	**Highly Acceptable**
Overall Mean	**3.70**	**Highly Acceptable**

Source/s: End Users' Evaluation Tool on the Level of Acceptability

Table 3 reveals that end-users' acceptability evaluation yields a Highly Acceptable overall rating (M = 3.70), indicating strong user approval of Uni-HEALS during the pilot implementation. The highest-rated items: accessibility and usability across different user types (M = 4.00) and effective integration with existing infrastructure and workflows (M = 4.00) suggest that the system was well aligned with the operational needs of the university clinic. These outcomes can be attributed to the system's role-based access design, intuitive interface, and seamless interoperability with existing databases, which collectively reduce user effort and support efficient task execution. The high rating for interface usability (M = 3.80) further underscores the effectiveness of the semantic search module, which supports natural

language queries and simplifies information retrieval, thereby reducing cognitive load and improving the user experience.

High acceptability ratings for real-time updates, responsiveness, system stability, and sustainable record management (all M = 3.60) indicate that Uni-HEALS consistently delivered timely feedback and reliable system performance. These strengths are closely associated with the system's optimized data processing and forecasting analytics, which support continuous monitoring and proactive planning without compromising system stability. Such features extend the system's functionality beyond basic digitization and contribute to sustained operational efficiency.

These findings are consistent with prior studies demonstrating that ease of use, system integration, responsiveness, and decision-support capabilities are critical determinants of user satisfaction and acceptance in healthcare information systems (DeLone & McLean, 2003[16]; Petter, DeLone, & McLean, 2008) [17]. Research further indicates that systems incorporating intelligent search and analytics achieve higher acceptance due to improved workflow compatibility and perceived usefulness (Wager, Lee, & Glaser, 2017) [18]. Compared with conventional university health systems that primarily focus on electronic record storage, Uni-HEALS delivers greater value through semantic search and forecasting capabilities, reinforcing its status as a highly acceptable, user-centered, and sustainable healthcare management solution for academic institutions.

Table 4. Cost–Benefit Analysis of Uni-HEALS: Semantic Search and Forecasting-Enhanced University Health Care Management System

Category	Item / Component	Expected Benefits	Cost (Php)
Hardware Costs	Firewall, Server Computer, Client PCs, Routers, UPS, Network Switches, LAN Cables	Enables secure, reliable, and high-availability infrastructure for system deployment and continuous operation	**Php 855,200.00**
Software Costs	Operating Systems, Office Productivity Tools, HCI Platform, Antivirus, OpenAI Subscription	Supports system functionality, semantic search, forecasting analytics, data security, and productivity	**3,200,000.00**
Service Costs	Installation & Configuration, Maintenance & Support (1 year)	Ensures proper deployment, system stability, and sustained performance during initial operation	**150,000.00**
Total Implementation Cost			**Php 4,205,200.00**
Operational Benefits	Automated health record management, semantic search, and real-time forecasting	Faster retrieval of patient data, reduced manual processing, improved decision support	
Efficiency Gains	Reduced processing time and administrative workload	Increased productivity of clinic staff and improved service delivery	
Data Security & Privacy	Role-based access control, secured infrastructure, and antivirus protection	Enhanced protection of sensitive health data and regulatory compliance	
User Acceptance & Satisfaction	High usability and accessibility	Faster system adoption, reduced training cost, and sustained system use	
Sustainability & Scalability	Modular, maintainable system architecture	Long-term cost savings, adaptability to institutional growth, and future system enhancements	

Table 4 shows the Cost–Benefit Analysis of Uni-HEALS: Semantic Search and Forecasting-Enhanced University Health Care Management System. The total implementation cost of the system was PHP

4,205,200.00, covering hardware, software, and service requirements to support a secure, analytics-enabled university healthcare management platform. Although the initial investment is considerable, it enables the deployment of a fully integrated system capable of semantic search, forecasting, and secure health record management.

From a benefits perspective, Uni-HEALS delivers substantial tangible gains, including improved operational efficiency, faster access to health information, reduced administrative workload, and enhanced decision support through predictive analytics. Additionally, intangible benefits such as strengthened data security, increased user acceptance, institutional trust, and long-term sustainability significantly enhance the system's overall value. Consistent with IEEE- and Scopus-indexed studies on system development, the benefits outweigh the implementation costs, indicating that Uni-HEALS is a cost-effective, scalable, and viable solution for university healthcare environments.

III. CONCLUSIONS AND RECOMMENDATIONS

The study showed that the development of the Uni-HEALS: Semantic Search and Forecasting – Enhanced University Health Care Management System was successfully carried out following the stages of the Modified Agile Development Life Cycle, including planning (requirements gathering), designing, development, testing, deployment, and maintenance. The system effectively addressed the operational needs of NEUST's University Infirmary/Clinic by integrating semantic search powered by natural language processing, linear regression–based forecasting, and role-based access control, along with secure data encryption and storage.

Evaluation results from IT experts rated the system as excellent in terms of security, usability, performance efficiency, and functional suitability, with noted opportunities for improvement in interoperability and support for additional environments. End-users likewise provided high ratings for usability and functional performance, confirming the system's practicality, efficiency, and user-centered design. The high level of acceptability further demonstrates that Uni-HEALS enhances workflow efficiency, ensures reliable and secure healthcare management, and is suitable for institutional deployment within NEUST's University Infirmary/Clinic.

Although Uni-HEALS was successfully developed using the Modified Agile Development Life Cycle and attained an excellent quality rating, continuous system enhancement is recommended. Regular updates and refinements should be implemented to improve further functional appropriateness, interoperability, and adaptability to emerging healthcare and information technology requirements.

Future versions of Uni-HEALS should incorporate standardized healthcare data exchange protocols (e.g., HL7 or FHIR) and expand compatibility with other institutional systems to enable seamless integration with external health information systems and databases. To further enhance system reliability, improvements in user error protection, automated backup, and recovery mechanisms are also recommended to minimize data loss and downtime.

Regular user training and orientation programs should be conducted to ensure optimal utilization of system features and improve operational efficiency. Given the high level of user acceptability, full deployment of Uni-HEALS across NEUST University Infirmary/Clinic operations is recommended, supported by updated institutional policies and procedures. Future studies may extend the system by integrating advanced analytics or decision-support features and by validating its scalability and effectiveness in other healthcare settings.

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