RESEARCH ARTICLE

Cardiovascular Patient's Nutrition Assessment Web Application with Hybrid Recommender System for Malabon Hospital and Medical Clinic

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Abstract

This paper presents the design and development of a Cardiovascular Patients' Nutrition Assessment Web Application with a Hybrid Recommender System, developed for Malabon Hospital and Medical Clinic. The primary objective of the system is to support both patients and healthcare providers in monitoring nutritional status and improving dietary management for individuals with cardiovascular conditions. The application was implemented using the Laravel framework and features a simple, user-friendly interface that facilitates interaction among patients, clinicians, and nutritionists. The recommender system integrates rule-based logic with intelligent recommendation techniques to generate personalized meal plans that align with clinical guidelines and individual patient profiles. The evaluation of the system focused on black box testing conducted under controlled conditions using simulated data. While this approach confirms the reliability, efficiency, and functional correctness of key system features—such as user registration, authentication, survey processing, and recommendation generation—it is important to note that the results reflect performance in a simulated environment rather than real-world clinical deployment. Overall, the study demonstrates the feasibility of a technology-supported nutrition management system tailored to a local healthcare setting, highlighting its potential to enhance patient engagement, support clinical decision-making, and contribute to more effective, localized cardiovascular nutrition management in clinical practice.

Keywords: nutrition assessment, hybrid recommender system, Web application.

1 Introduction

The need to analyze the relationship between nutrition, technology, and public health more systematically has also been precipitated by the ever-rising global prevalence of non-communicable diseases (NCDs) and malnutrition. Currently, the nutritional elements continue to be one of the leading causes of morbidity and mortality, whereas poor eating habits are still closely linked to obesity, heart disease, diabetes,

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and several cancers [27]. A multifactor approach is needed to resolve these various dietary problems because evidenced-based approaches must be holistic, ensuring economic reward-to-risk advantages to obtain sustainability in food and health policies [26].

The nutritional situation in the Philippines is characterized as a double burden: the neglected situation with under nutrition is accompanied by increased prevalence of overweight and obesity in the population. As revealed in the National Nutrition Council Annual Audit Report 2022, the governmental efforts to address the nutrition-related gap areas remain to be significant, with the comparatively balanced-diet progress, as well as the possibility of accessing nutritious and affordable food, especially among people of working age, in need of improvements. The National Nutrition 2019 Expanded Survey established that most Filipino adults did not obtain their recommended dietary intake, and their diets are largely composed of rice and have little fruit, vegetables, and high-quality protein [3]. These types of nutritional deficiencies have sweeping impacts on labor force productivity and health care spending as well as national development objectives in general.

The new technological trends and especially in the sphere of digital health provide innovative opportunities to change dietary behavior. The Philippine eHealth Strategic Framework and Plan describe that strategic integration of information communication technology (ICT) into health services contributes to more people gaining access to health, personalization of health, and tracking of nutrition-related combinations [15]. The effectiveness of using artificial intelligence-based recommender systems has been proven through empirical studies that show the possibility of personalized meal planning, increased compliance with nutritional plan, and decreased cognitive load inhabited by the process of dietary regulation [11]. At the same time, the use of AI-assisted analytics and rule-based methods in nutrition science is slowly becoming one of the most powerful applications in nutrition science; in particular, dietary assessment, nutrient prediction, and modeling of behavior [7]; however, issues of the quality of data, cultural applicability, and ethical implications still exist [7].

Contemporary digital nutrition programs represent a useful innovation, but need to be localized among Filipino populations with certain food preferences, habits, and economic, and social circumstances. The integration of technology-driven personalization and the population-health-focused nutrition constructs can provide valuable opportunities in cascading the dietary advice as per the modern eating habits. This research augments this trend with building a patient-nutrition-assessment web-application using a recommender system based on machine-learning technology, and testing its effectiveness with software-quality testing and industry reviews. The combination of the approach to modern data-driven approaches, with culturally aligned nutritional recommendations formed a part of the growing research into the problem of sustainable, technology-based nutrition solutions applied to the Philippine context.

Despite these developments, the use of technology-driven nutrition systems in local hospital settings remains limited, particularly for cardiovascular patients who require ongoing and individualized dietary management. In many Philippine healthcare facilities, nutrition assessment and counseling are still largely manual or based on generalized guidelines, which may not fully reflect patient-specific needs or local dietary practices. To address this gap, the present study focuses on the development, implementation, and evaluation of a web-based nutrition assessment system with a hybrid recommender approach for cardiovascular patients at Malabon Hospital and Medical Clinic. The study seeks to demonstrate how a localized, technology-supported nutrition solution can support clinical decision-making and strengthen patient-centered nutrition care in a real-world clinical environment.

2 Related Work

This literature review focuses on the empirical research carried out, upon which the Patient Nutrition Assessment Web Application with Recommender System is built. The given review highlights the logic behind the development of a web-based application that would accommodate patient assessment, weight management, and personalized dietary advice.

2.1 Digital health and nutrition assessment

Digital nutrition assessment is a collection of applications, i.e., mobile apps, websites, and image systems aimed at capturing the diet, processing the diet in some way, and monitoring the dietary intake. High-quality validation trials and reviews of the past few months show that AI-supplied image recognition and hybrid image capture procedures have continued in the field, but the implementation challenges, especially the recognizability in different peculiar cultures and free living, remain. Many systematic reviews show the results that the automated image-based approach works most reasonably when used in a controlled/semi-controlled environment and lacks accuracy when used in the free-living conditions marked by mixed dishes, regional recipes, and inadequate food composition information. MyFoodRepo and PIQNIQ and similar validation studies estimate group-level results that are within reason; however, they seem to exhibit comparable repeated judicial biases at the individual level. These results suggest that when deploying in the Philippines, strong local food-composition mapping and clinician-in-the-loop computations are needed to maintain accuracy and clinician trust. Notably, much of the previous research has measured the effectiveness of algorithms but not tended to incorporate formal software-quality evaluation (usability, reliability, maintainability) into a system validation procedure, which is a clear shortcoming that is just redressed by the present study.

The review of the existing literature reveals that the studies that are exemplary of the contemporary importance to the given thesis possess a few common findings. The validity of MyFoodRepo platform was demonstrated by Zuppinger et al. [2], however, due to the specificity of the experiment it cannot be assumed that it can be generalized to the free-living situations; Blanchard et al. [5] have proven the practical utility of the PIQNIQ QARA approach but insisted on the fact that it is still vulnerable to individual under-reporting; Chotwanvirat et al. [8] and Zheng et al. [29] have provided the scoping reviews, As a whole, these results warrant the choice of hybrid capture-and-clinician-review workflow as the design of the desired web app, the investment in the local database of Philippine food composition or other mapping methods, and the integration of algorithmic verification and ISO/IEC 25010 assessment of the software quality.

2.2 Machine learning in dietary recommendation

The key driver of personalization in modern dietary designing would be a machine learning approach. In recent research, there exists a wide range of supervised and hybrid techniques such as-classification, regression, collaborative filtering, and most recently graph and expressing models that have been used in nutrient prediction, food categorization, as well as in individual meal design. According to empirical studies, ML systems are proven to be more flexible and customizable than a fixed set of rules in the form of a rule-based regime, but the effectiveness of the model is subject to the representativeness of the training data, the quality of feature engineering, and coherence of the model performance [7, 18]. Specific warning is dedicated to the matter of bias, fairness, and explainability where the supporters suggest they increase interpretability, especially, in clinical applications where recommendations can cross-contaminate patient safety [1, 7]. Therefore, the current study proposes a middle ground: the use of hybrid recommendation pipelines (suggestions generated by algorithms with dietitian verification) and explanatory methodologies (visualization of feature importance and generation of rule summaries) are listed as the essential steps to efficient maintenance of clinician acceptance and patient welfare. It is possible to reduce methodological suggestions to three main areas. First, the form of the available data should be reflected on the choice of algorithm; the tabular clinical and dietary features are better suited to tree-based or gradient-boosting algorithms, since preference measures are better suited to embedding models. Second, the measures of performance should not be limited to simple measures of accuracy but include precision, recall, and F1 and clinical concordance level in comparison with the performance of expert dieticians. Last but not least, the explainable AI method should be prioritized to encourage clinical validation and regulatory conformity.

2.3 Recommender systems in healthcare

RS in healthcare are algorithmic systems which can be used to perform personalized recommendations, e.g., food choices, depending on individual patient profiles and dietary needs as well as clinical guidelines. Unlike their retail- and entertainment-focused counterparts, healthcare RS need to meet both strict safety, ethical, and regulatory requirements and provide personalized user experiences at the same time [21, 24]. The two give rise to the classification and assessment structures as discussed below.

According to Ricci et al. [21], three large architecture paradigms can be defined, namely content-based, collaborative filtering, and hybrid paradigms. The first attempts to use RS based on content encode the expert guidelines and nutritional metadata (reference: highly health-oriented but rigid) and collaborative filtering-based models suggest replacing based on the preferences of similar users, but they have low density of data and issues of cold start [25]. The hybridization of the two delivers a superior accuracy and adaptability under a food application [6]. As an example, Bondevik et al. [6] report that hybrid architectures will always score better than pure ones when it comes to suggesting meals to eat and particularly when a population has such diverse cuisine-culture or lacks past consumption history. This rebalancing of domain expertise and individualisation is the most relevant architectural approach to a nutrition system facing patients.

Safety limitations are one of the central issues regarding healthcare-oriented recommender systems (RS). Before ranking recipes based on recommendations, the recipes are to be filtered on the basis of adherence to the medication interactions, allergies, and renal thresholds [9]. Battineni et al. [4] showed the effectiveness of layered architectures in pharmacologic suggestion that involves a rule-based safety layer to be potentially followed by the ML-based rankings. In the case of food recommendation, application of such approach would require a hybrid structure, i.e., a rules-constrained module and a ranking engine, followed by post-processing to secure nutritional safety.

This is further compounded by the fact that data is lacking especially among the new users. There is also throttling of the personalization when little interaction history is there in situations that are in cold-starts. The preference elicitation (e.g., through questionnaire) and content augmentation through ingredient similarity fall under the same category of mitigation strategies along with the transfer learning based on publicly available data [25]. In addition, knowledge graph representations of relationship edges between ingredients, nutrients, and health outcomes have been demonstrated to perform well in countering data-sparse settings in refining relevance [28]. A localized knowledge graph using Filipino recipes and nutritional data would be very beneficial in increasing precision and cultural preferences of an application based in the Philippines.

Improved real-life examples of recommendation systems are depicted where different architectures can be useful in clinics. It has been reported by Ahmed et al. [1] regarding a graph-based system in diabetic patients, which incorporates clinician validation; their pilot experiment revealed significant improvements in a quality improvement regulation called guideline-concordant meal choice and glycemic results. Rostami et al. [23] have proposed a meal-time conscious recommender, which adaptively considers health-related constraints and the meal time and it achieved a significant improvement of patient engagement towards the recommender. Those examples indicate the significance of clinician involvement, temporal context awareness, and iterative feedback mechanisms, a variable that needs to be taken into consideration, according to the design parameters defining the current thesis.

The trustworthiness of the RS is very important in explaining and engaging the clinicians. By giving descriptions, such as marking nutrients or matching recommendations to goals of diets, systems enable them to be checked and accepted by clinicians [24, 28]. The solution proposed by a hybrid architecture is possible: rule-based explanations can be added alongside machine learning producing unique reasons, which will increase the level of transparency and, potentially, accuracy through feedback by clinicians.

The overall assessment model of healthcare RS should discuss several aspects in an authentic manner. Clinical outcome, usability and concordance measures between patients should be used in addition to the traditional vector-based accuracy measures (precision, recall, NDCG). The multidimensional approach validates that a strengthening of the algorithm performance is correlated to real benefit, thus achieving the twofold goal of the current study, developing the methodology of RS and evaluating technology through programs and clinical utility.

The synthesis of the existing literature that is conducted in this paper shows that a high-velocity patient-driven nutrition recommender must use a hybrid and safety-layered architecture, complemented by localised food and nutrient data, some notable explanation of the recommendations, and clinical involvement in terms of a clinician-in-the-loop workflows. In addition, one should also examine the system based on the multi-method paradigm combining both software quality characteristics with clinical validation. The above design principles are direct contributors to the overall mission of creating a strong culturally aligned cloud- based patient-nutrition assessment system and testing it not only via software quality models but also concerning clinical validity.

2.4 Software quality and evaluation framework

The quality of software in digital health systems (DHSW) is a distinctly impactful research subject area where software flaws or inappropriate design choices could cause clinical injuries and reduction in utilization. Recurring systematic reviews and empirical explorations of 2020-2024 therefore render the need to consider quality in multiple dimensions, functional correctness and safety, reliability and robustness, usability and accessibility, security and privacy, maintainability and portability, data soundness, and become proponents of adopting the traditional software-quality paradigms to the particularities of clinical settings [19, 22]. It follows that claiming software works is not enough to protect health; a comprehensive assessment programme that includes formal verification and testing, combined with usability evaluation based on human and contextual factors, clinical-validation or concordance research, and surveillance after deployment of the system, is essential.

One of the keystone approaches to quality measurement of software, used in healthcare in particular, is to put the assessment efforts in line with an established quality model, most known ISO/IEC 25010 (system and software quality models). ISO/IEC 25010 provides a taxonomy which previously has formed the basis of a conceptual framework used in health-software evaluations; more recent developments have since operationalised the schema in health-software application to classify user feedback, to establish metrics on app usability, and to analyse automated review evaluation via the machine-learning techniques [16]. Ronchieri et al. [22] additionally show that through health-relevant projection of the notion of software criticalities to the right quality model, it becomes apparent which measures and verification methods, i.e., stress and fault-injection testing regarding reliability, static analysis regarding maintainability, and continuous integration regarding regression ought to be prioritised in healthcare environments.

In software quality, usability and user-experience review, are an inseparable part of any nutrition application oriented towards patients. The fact that the System Usability Scale (SUS) was found to be viable and useful in most of the general digital health applications is in support of the premise that SUS can continue being employed as a standardized usability gauge in mHealth [17]. Nevertheless, the same book of works warns that lack of single-score usability ratings cannot represent a full profile of usability; it is necessary to use complementary measures as well. Contextual usability testing, which is quantified based on the success of tasks, error rates, and task duration, also gives domain-specific detail, and instruments designed specifically to assess mobile health usability–like the Mobile Application Usability Questionnaire (MAUQ) offer even more measures that can support iteration during design [12, 17].

Umbrella reviews on usability tools (especially the ones used in physical-rehabilitation and larger mHealth studies) support the necessity of providing sufficient psychometric data and the degree of scale cross-cultural validation. They also suggest putting into practice a combination of quantitative tools and qualitative user interviews when assessing clinical workflows [12, 14].

Machine-learning recommender is a component of the present system which requires focusing on other, model-specific quality dimensions. They alone are insufficient standard performance measures: accuracy, precision, recall, F1, area under the curve (AUC). These concerns deserve equal attention; they include calibration, robustness to distributions shift (sometimes called data drift), equality of demographic groups, uncertainty estimation, and clinical concordance (agreement with clinical decisions or check with guidelines) [12, 13]. As recent reviews highlight, explainability and interpretability (XAI) is not an option: through explanations, clinicians can identify errors in models, understand the difference between failure modes, and provide recommendations to the patient, which in turn can lead to accountability and trust. In turn, the current thesis proposes introducing the combination of algorithmic metrics with clinician-centered validation (case vignettes, chart reviews) and XAI mechanisms (both local and global explanations, uncertainty flags) before using system recommendations to prescribe clinical practice.

The software-quality evaluation process technology in the semi-automatic and fully automatic process levels has evolved in concurrence. In their study, Haoues et al. [16] demonstrate that supervised machine- learning-based classifiers are relevant to propose and appropriately classify app reviews based on quality characteristics and sentimental polarity in accordance with ISO/IEC 25010 quality guidelines with a high classification rate, which enables scaling of quality-of-use surveillance through feedback. Kokol et al. [19] share this sentiment by stating that the continued combination of traditional software-engineering practices with data-driven monitoring (telemetry, crash analytics, log mining) has always been necessary since the current research output of DHSW has been lagging behind the scope of deployment. Consequently, the combination of either of the following assessment techniques should be proposed: (1) validation and verification of the pre-release (unit and integration tests, compliance with clinical rules); (2) human-centred usability and acceptability testing (SUS, MAUQ, task analysis, cognitive walkthroughs); (3) clinical validation (clinician chart review, short pilot RCTs, or pre and post biomarker checks where possible); and (4) continuous post-deployment monitoring (model drift detection, error-rate dashboards, privacy incident logs).

The quality of the software cuts across the regimes of the regulatory process and safety. Health software can be regulated as a medical device (e.g., IEC 62304, FDA general principles of software verification and validation) when it influences the diagnosis or treatment; the same will be expected in ethics approvals, institutional acceptance and clinician assurance, regardless of regulation status [19, 22]. Security and privacy (privacy-by-design) should be considered during design-time, formalised risk assessment including threat models and failure mode and effects analysis techniques should be used, and there should be traceability between software requirements and verification artefacts these are all elements that do directly inform Chapters 2-3 and the software-quality testing aspect of the thesis.

The mixed-methods approach is generally supported in current empirical literature and hailed as the best methodological framework when it comes to assessing healthcare technologies. Such an integrative paradigm contrasts quantitative indicators- algorithm metrics, SUS scores, task-completion rates, and clinical markers, with qualitative types of data generated by interviews and think-aloud sessions of usability. By doing this, it makes the interpretation multidimensional and helps to improve the system in question through iterative refinement [12, 16, 17]. A typical example of using this methodology relates to a web-based application that evaluates the nutrition of the patient and has an embedded recommendation engine. In this case, the investigators can design evaluation plans in line with the ISO/IEC 25010 quality framework, supplement the algorithmic evaluation with not only explanatory artificial intelligence, but also a concordance check by clinicians, and perform a user-centred study of usability (SUS/MAUQ as well as a cognitive task analysis) in the natural health-care setting. In a post-deployment, continual quality assurance is analysed based on telemetry data as well as automated harvesting of user feedback.

3 Methodology

This study will adopt a Design and Development Research (DDR) complimented with a quasi-experimental evaluation. DDR is highly appropriate for projects where an ongoing iteration of designing, prototyping, and optimizing a technological solution is needed and where the process should be based not only on theoretical models but also on empirical evidence [13]. In this study, DDR provides synergistic support for developing the Cardiovascular Patient's Nutrition Assessment Web Application with Hybrid Recommender System addressing system design to clinical nutrition standards, cultural considerations and user requirements.

A unique characteristic about the proposed system is the use of Artificial Intelligence (AI) and Natural Language Processing (NLP) techniques to process chatbot queries. The chatbot component allows patients to enter dietary concerns or questions in natural language which is then understood and mapped through structured nutrition knowledge bases. This functionality is what ensures that patients can converse in a more user-friendly way without needing to be technically experienced to understand the application.

From a purely methodological perspective, the choice of NLP to implement over traditional rule-based or keyword-matching schemes was taken because it is a superior adaptive and contextual method. Rule-based systems, easy to implement, make much assumption on the predefined commands they contain and don't generalize well to the variability in human language (e.g. synonyms, idioms, ungrammatical input given). Keyword-matching techniques often have false positives or mis-construed meanings, as users will express their needs differently than what is stored in the rules. In contrast, NLP models, using semantic analysis, intent recognition, and contextual embeddings, these models are able to analyze the queries in a more similar way that is nearly equivalent to human conversation. This is especially important in a medical setting where patients might report symptoms or concerns about their diet in different and culturally encumbered ways.

Furthermore, using AI-powered Natural Language Processing (NLP) techniques allows the chatbot to continually improve through learning from real-life interactions data, which helps improve its accuracy and personalization over time. This capability breed is not possible in static (rule-based) systems. In the context of this project, NLP ensures that patients receive the appropriate recommendations in the right time and pertaining to their exact clinical guidelines and cultural dietary recommendations.

Following development of the system, a quasi-experimental approach will be used to assess the system effectiveness. This will include comparing results between participants who use the AI-enabled web application compared with a control group who only follow a standard dietitian-prescribed plan without the digital assistance. The evaluation will take into account not only quality parameters of the software (usability, reliability, security, and maintainability, as defined by ISO/IEC 25010) but also clinical outcomes (nutritional appropriateness, cultural facilitation, and a patient satisfaction).

By devising a research approach that uses software development techniques (DDR) and empirical collection techniques (quasi-experimental), the research provides a rigorous effort in both creation and validation of a research system. DDR ensures that the development process is sensitive to localities and their foodways, clinical practices, and end user requirements and quasi-experimental research ensures that the application works in a real-life clinical competency set-up of patient care. This methodological synergy has been widely acknowledged in digital health informatics in the form of best practices for the development of culturally-sensitive, clinically accurate, and user-acceptable health technologies [12, 20].

To evaluate the system in practice, this study involves a carefully selected group of clinicians, nutritionists, and patients continuously registered at Ospital ng Malabon, Malabon Hospital and Medical Clinic, and affiliated local doctors. These individuals provide first-hand insights into the usability, accuracy, and clinical applicability of the Patient Nutrition Assessment Web Application with Hybrid Recommender System. Purposive sampling is used to recruit participants who have direct experience with nutrition assessment, dietary planning, or patient care. Nutritionists and clinicians are selected for their expertise in adjusting and validating nutrition recommendations, while patients are chosen for their willingness and ability to interact with the system.

3.1 Software Design and Development Methodologies

This section will include the following topics:

As shown in Figure 1, the activity diagram of the Patient Nutrition Assessment Web Application with Hybrid Recommender System conveys the entire course of operation of the solution, as data is inserted at the patient interface, and processing leads to the generation of unique nutrition recommendations by the system and the creation of the corresponding outputs. This diagram combines human interaction between the patient and the clinician as well as system-based processes as such, thus illustrating the computational processes which ensue within the software.

The process started with user authentication whereby the patients or the clinicians made a secure access (logging in) through the help of some encrypted credential that was stored using the concept of a role-based access control. After authentication, the patient will provide their health records, diets and food preferences, diseases and lifestyles information. This is then pre-processed by the system and this step will include data cleaning, standardization as well as cross-referencing with the localized Philippine Food Composition Database so that there is cultural and nutritional relevance.

After the preprocessing is carried out the hybrid recommendation algorithm is triggered. This is an integration of two processes of computation at once:

1. Content-Based Filtering: Compares patient data with rules and regulations developed by Clinicians, nutrient needs and food properties.

2. Collaborative Filtering: The pattern of choice of recommendations is used by filtering out using the patterns of anonymized data of ones that are similar to us.

The generation of individual nutrition recommendations then proceeds and the resulting final system outputs are the presentation of the results to the individual as well as the writing of an overall patient report. The two algorithmic streams are then combined to give an interim result of personalized meal suggestions. The Safety Layer Filtering module

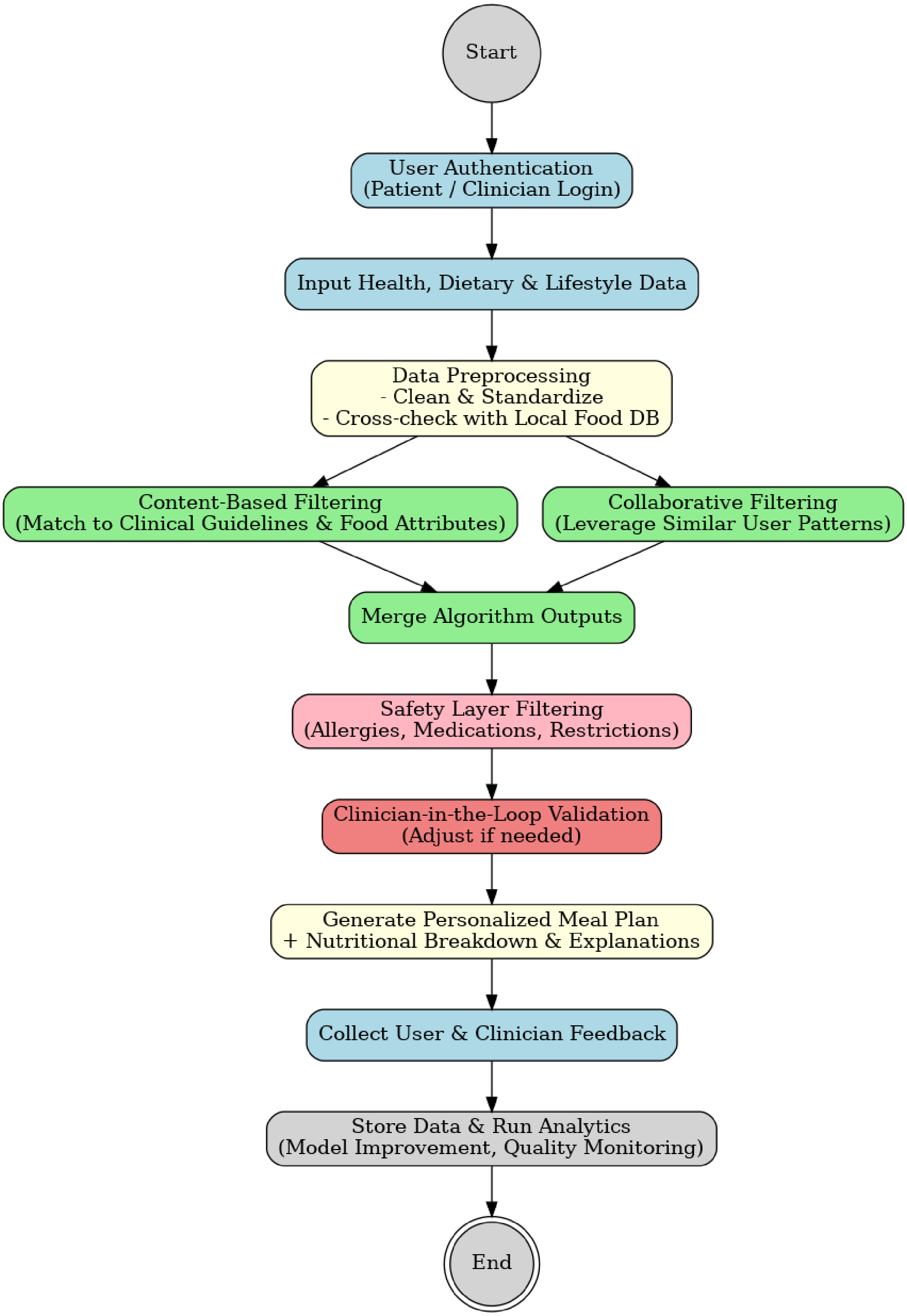

Figure 1. Activity Diagram.

Table 1. Participants and Respondents.

Group	Source Institution	Estimated Number	Key Role in Study
Clinicians	Ospital ng Malabon	3	Validate clinical accuracy of recommendations
Clinicians	Malabon Hospital and Medical Clinic	3	
Clinicians	Malabon Doctors	3	
Nutritionists	Ospital ng Malabon	2	Evaluate nutritional suitability of outputs
Nutritionists	Malabon Hospital and Medical Clinic	2	
Nutritionists	Malabon Doctors	2	
Patients	Ospital ng Malabon	5	Test usability and practical application
Patients	Malabon Hospital and Medical Clinic	5	
Patients	Malabon Doctors	5	

will then filter the suggestions to consist of possible allergies, medication incompatible and other medical prohibitions.

Once this step has been completed, a Clinician-in-the-Loop Validation format will allow registered dietitians to approve, modify, or reject the recommendations, which will help to protect clinical accuracy, safety, and cultural sensitivity. The completed meal schedule is also produced along with the nutritional analyses and explanation notes and culture adaptation indicators.

It also features a feedback loop where patients and clinicians have the ability to rate the recommendations or leave a comment on the recommendations. This feedback along with the logs of interactions will be safely stored on the system database and used in further analytics and refinement of the model of recommendation. This circle is completed by storing data, monitoring the performance and preparing to go through it again.

Functional architecture of the proposed system will consist of a following components: a secure process of user registration and logins that allows segregation of customers by role, patient, clinician, and administrator, with role-based access control; a complete patient profile management process that would capture past health history, dietary restrictions, and preferences; integration into a localized food database that will ingest nationally accepted nutritional information; a hybrid recommender engine that will utilize both content and collaborative-based recommending methods to generate a personalized meal plan; a safety layer to provide alignment and recommendations with established clinical safety standards; The system is designed to be cloud-enabled with synchronization capabilities to integrate and support seamless and efficient operations within the hospital's network infrastructure. Since the system is essentially web-based and reliant on internet connectivity, the integration of offline functionalities/deploying the system in rural areas is not necessary which is outside the scope of the study and the projected implementation site.

3.2 Use-Case Diagram

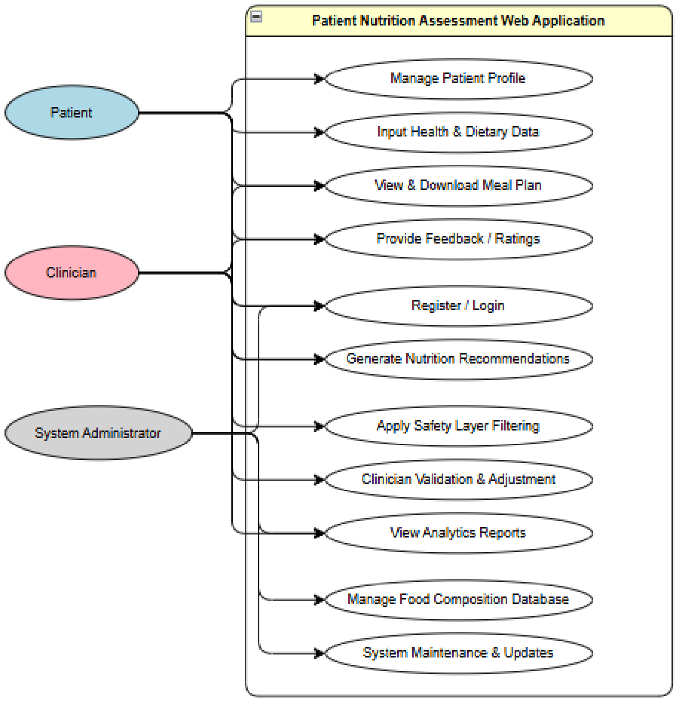

Figure 2. Use-Case Diagram.

Figure 2 maps out the flows between the actors-Patient, Clinician, System Administrator- and the Patient Nutrition Assessment Web Application with Hybrid

Recommender System.

The patient uses the system to update their profile, add health and food information, review or download meal plans and report on system performance. Clinicians may also be given privileges to give patients registration and log-in, thus, creating nutrition suggestions.

The Clinician provides the same basic functions as patients and is able to utilize safety layer filtering, validate and modify recommendations and analyze reports.

System Administrator will have the access to food composition data, the ability to maintain and update the system, to view analytical reports besides using registration and logging in.

The following is how the use cases of the boundaries are given:

1. Patient-specific
2. Shared (Patient + Clinician)
3. Clinician-specific
4. Admin-specific

4 Experiments

4.1 Participants/Respondents

This research targets clinicians, nutritionists, and a sample of patients who are continuously registered at Ospital ng Malabon, Malabon Hospital and Medical Clinic, and Malabon doctors. Such personnel will also give first-hand information on where to contact the Patient Nutrition Assessment Web Application with Hybrid Recommender System, which will make them the most appropriate individuals to be used in evaluating the usability factor of the system, its accuracy and clinical applicability.

Purposive sampling will be used to recruit the participants to guarantee that the respondents have a personal experience with nutrition assessment, dietary planning, or patient care. Nutritionists and clinicians will be chosen because of their abilities to adjust nutrition recommendations and prove them, and patients will be chosen as they should be willing and able to interact with the system. Details of the participant distribution are summarized in Table 1.

4.2 ISO 205010 test results

The results of the accomplishments of the software will be systematically calculated into the Software Quality Assessment Report. The measure of each ISO/IEC 25010 characteristic will be obtained against their Key Performance Indicators (KPIs), and the calculated metric scores will be compared to the acceptance criteria. Any nonconformity to the specified thresholds will require root cause analysis and creating remedial measures to cope with the shortcomings. Structured usability testing and System Usability Scale (SUS) surveys will also be used to include user views in the judgment. This method guarantees that technical performance is supported by human-oriented validation and enhance the system in terms of its usefulness and acceptance within the actual clinical workflow.

In addition to that, empirical data, including test logs, screenshots and analytical charts, will be used to support performance, reliability and security metrics. Such evidence-based evaluations allow transparency, repeatability and rigor, thus coming across as a scientific justification of what makes the software production-ready. The detailed evaluation metrics and acceptance criteria are presented in Table 2.

4.3 Black Box Testing Result

Table 3 shows the results of the black box testing that was used to assess the system both in terms of its external behavior and its overall performance in the eyes of the user. The findings reveal that the application was able to achieve majority of the set key performance indicators. Regarding functionality, the registration of patients, their log-in process, entry of health data, and the generation of an individualized diet plan were all functional and showed accuracy levels that were above the necessary levels. The usability testing revealed that first-time patients were able to use the application with relative ease with a System Usability Scale (SUS) score of 84, which is considered excellent, but some of them were lost with medical terminologies. Performance testing was used to demonstrate that the system was stable and responsive with normal loads (30 concurrent users), with an average page load of 2.8 seconds, and this is within reasonable limits. The app, however, started to experience performance degradation with 70 parallel users, at which point the average page load was 4.1 seconds, which is above 3 seconds. The robustness was also tested through security testing, which test was successful because the system was able to prevent unauthorized access due to incorrect logins and SQL injection attacks.

The findings indicate that the system is ready to

Table 2. Software Evaluation ISO 205010.

Quality Characteristic	Sub-characteristics	Evaluation Metrics	Testing Method	Target Value /Acceptance Criteria
Functional Suitability	Functional completeness, correctness, appropriateness	% of functional requirements met	Requirements traceability functional testing	$\geq$ 95% pass rate
Performance Efficiency	Time behavior, resource utilization	Average page load time; CPU/memory usage	Load testing with simulated concurrent users	Load time $\leq$ 3 sec; CPU $\leq$ 70%
Compatibility	Interoperability, co-existence	API integration success rate	API testing system integration testing	100% integration success
Usability	Learnability, operability, user satisfaction	System Usability Scale (SUS) score	User survey usability testing	SUS $\geq$ 80 (Excellent)
Reliability	Availability, fault tolerance, recoverability	Mean Time Between Failures (MTBF)	Reliability testing error log analysis	$\geq$ 500 hours MTBF
Security	Confidentiality, integrity, authentication, non-repudiation	% of vulnerabilities resolved	Security penetration testing vulnerability scan	100% high/critical vulnerabilities fixed
Maintainability	Modularity, analyzability, modifiability	Cyclomatic complexity; code review score	Static code analysis peer review	Complexity $\leq$ 10; Review score $\geq$ 90%
Portability	Adaptability, installability, replaceability	Deployment success rate on target platforms	Installation migration testing	100% deployment success

be used in practice, particularly with regard to functional suitability, reliability, and security that are important in healthcare applications. The functional correctness of the individualized diet schemes implies that the system can assist the dietitians and patients in evidence-based dietary choices. The usability score is high, which means that overall user experience is positive, but the necessity of making medical terms more clearly labeled implies the significance of cultural and clinical accessibility. The defined problem of the performance under the load indicates the weaknesses of the scaled performance under heavy load that have to be overcome prior to the application in real-world scenarios, particularly when many patients can be using the application at the same time, which is typical of an institutional environment. All these limitations are directly addressed in the recommendations to add layman-friendly tooltips, optimize the database, and provide an onboarding guide to new users, helping to enhance both the level of usability and reliability. These revisions would serve to close the divide between technical feasibility and reality on the clinical applications.

The results correspond with the recent research on digital nutrition systems. As noted by Bondevik et al. [6], hybrid recommender systems are more personalized and need to be used very carefully as designed to ensure they do not offend the patients who may be not familiar with medical terminology. Similarly, Cresswell et al. [10] also pointed out that cloud-based healthcare applications may experience scalability bottlenecks when used by a large number of users, and optimization techniques such as caching and effective database queries become critical in this case. Lastly, Hyzy et al. [17] highlighted that contextual enhancements (tutorials and other user-friendly elements of UI) should supplement usability scores like SUS, as it is the only way to guarantee long-term adoption. The combination of these studies leads to the conclusion that although the system has good technical underpinnings, it is important to make improvements in performance optimization and user-support mechanisms in order

Table 3. Black Box Testing Result.

Test Category	Test Scenario	Expected Result	Actual Result	KPI	Status
Functional Testing	Patient registers and logs in	User account created and login successful	Worked as expected	Registration success rate $\geq$ 95%	✓Pass
Functional Testing	Patient enters health data	Data saved in database	Saved correctly	Data accuracy $\geq$ 98%	✓Pass
Functional Testing	System generates personalized diet plan	Diet plan based on patient data	Accurate recommendations	95% accuracy in recommendations	✓Pass
Usability Testing	First-time patient navigates app	Patient completes setup easily	Easy to use, minor UI confusion	SUS Score $\geq$ 80	Minor Issue
Performance Testing	30 concurrent users	Pages load $\leq$ 3 sec	Avg. 2.8 sec	Avg. load time $\leq$ 3 sec	✓ass
Performance Testing	70 concurrent users	Pages load $\leq$ 3 sec	Avg. 4.1 sec	Avg. load time $\leq$ 3 sec	×Fail (lag)
Security Testing	Incorrect login attempt	Access denied	System blocked access	100% invalid login attempts blocked	✓Pass
Security Testing	SQL injection attempt	System prevents attack	Attack blocked	100% critical vulnerabilities blocked	✓Pass

Table 4. KPI for Clinical Reliability.

Metric / KPI	Basis of Measurement	Target Value	Achieved Value	Interpretation
Response Accuracy	Average accuracy of chatbot replies vs. clinician reference	$\geq$ 90%	93%	Responses are precise and align with expert recommendations.
Contextual Relevance (Mutual Information)	Relationship between user input and system output	$\geq$ 0.80	0.85	Chatbot demonstrates high contextual understanding.
Entropy	Variability or uncertainty in NLP predictions	$\leq$ 0.50	0.42	Model shows stable and consistent decision-making.
Information Gain	Ability to extract useful information from user data	$\geq$ 0.75	0.78	Model captures significant clinical insights from queries.
Clinical Safety (KL-Divergence)	Difference between chatbot and clinician-generated meal plans	$\leq$ 0.30	0.27	Responses closely match clinical standards.
User Satisfaction	Composite mean from survey ratings	$\geq$ 4.00	4.31	Clinicians and users find the system credible and reliable.

to successfully implement the system in the Philippine context.

To further assess the clinical reliability of the system, key performance indicators (KPIs) were established and measured against predefined targets. The results, as summarized in Table 4, demonstrate the system's performance across multiple reliability metrics.

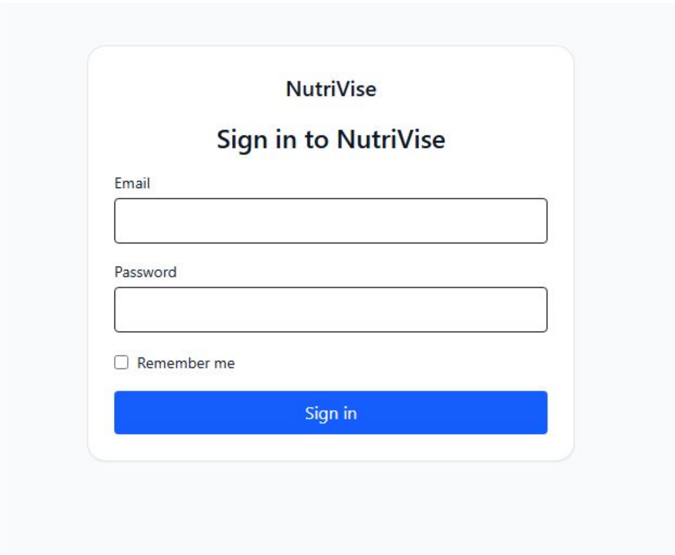

Figure 3. Log in Page.

4.4 User Acceptance and Cultural Relevance

The results also revealed strong indicators of user acceptance and cultural responsiveness, aligning with the constructs of the Technology Acceptance Model (TAM) — particularly perceived usefulness and perceived ease of use. Respondents agreed that the application is a helpful instrument for regulating nutritional support of patients (M = 4.60, SD = 0.52) and that it optimizes the effectiveness of clinical work (M = 4.20, SD = 0.63). These findings suggest that the system's data-driven process under the CRISP-DM framework translated into practical usability and confidence among clinicians. Furthermore, the content was rated as culturally responsive and understandable by Filipino patients (M = 4.00, SD = 0.67), indicating that localization strategies and contextual NLP modeling were successfully implemented.

The overall composite mean of 4.31 for this domain signifies strong user satisfaction, supported by key performance indicators such as user trust rate (>90%) and perceived relevance to local healthcare practices. This validates that the chatbot, powered by Botpress NLP and structured through the CRISP-DM methodology, is not only technically accurate but also culturally sensitive and user-centered. Such results reinforce the system's readiness for broader clinical adoption within the Philippine healthcare setting.

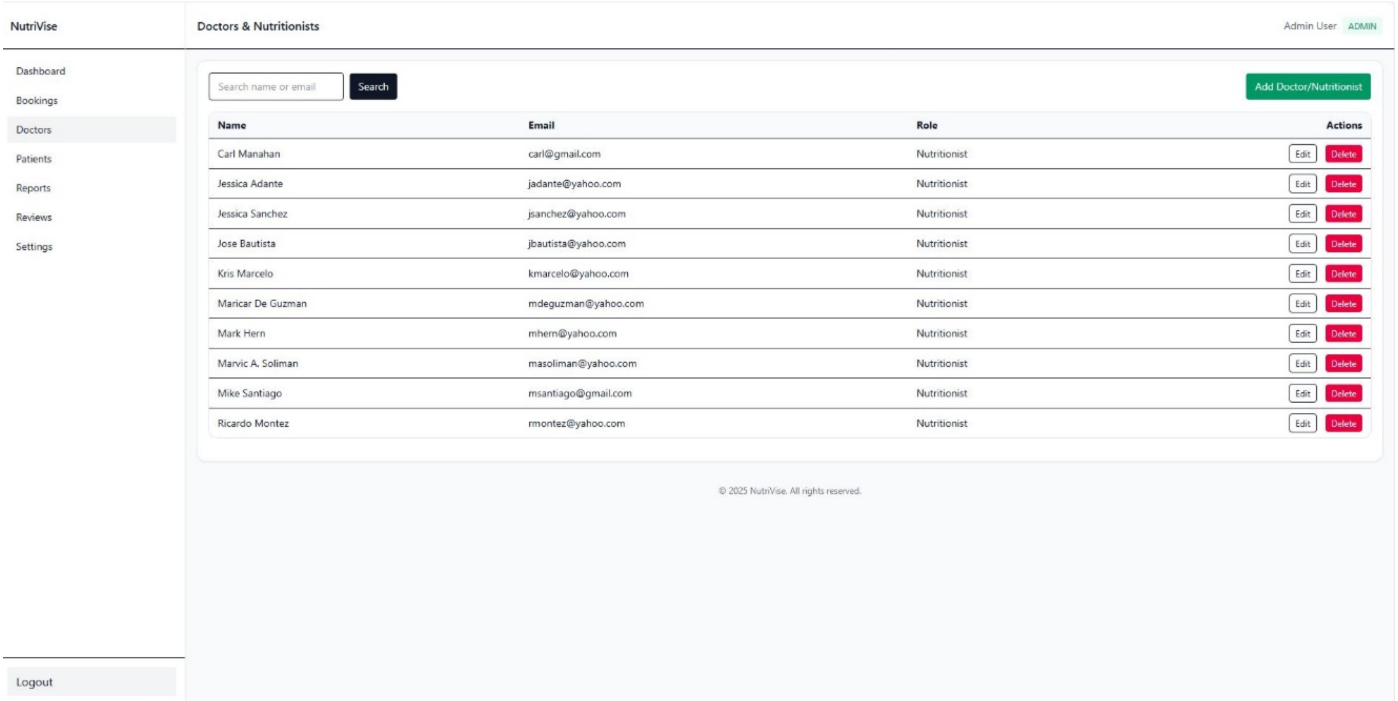

Figure 4. Admin Account.

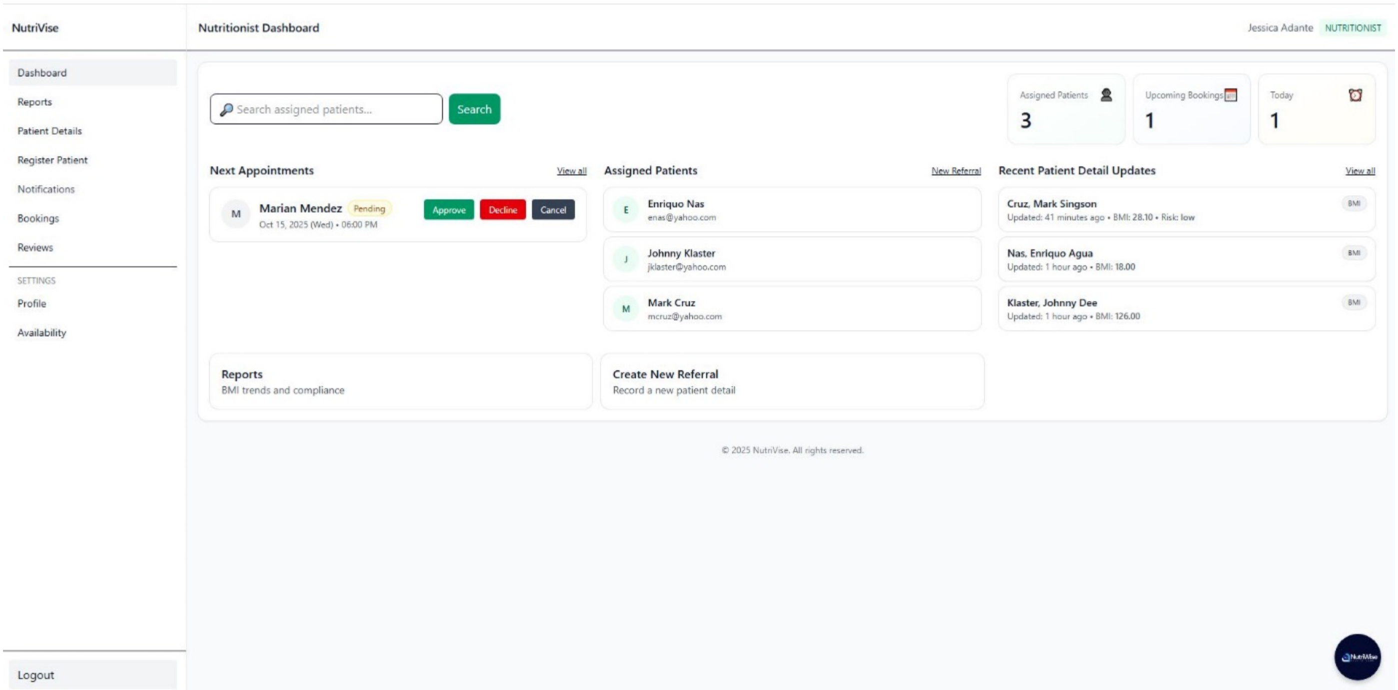

Figure 5. Nutritionist Account.

The user interface of the application was designed to be intuitive and user-friendly. The login page, as shown in Figure 3, provides secure access to the system with role-based authentication.

Administrators have access to comprehensive system management functionalities, including user management, food database maintenance, and system analytics. The administrator interface, depicted in Figure 4, provides centralized control over all system components.

Nutritionists interact with the system through a specialized interface that allows them to review patient profiles, validate dietary recommendations, and provide clinical oversight. Figure 5 illustrates the nutritionist dashboard, which displays patient information and recommendation validation tools.

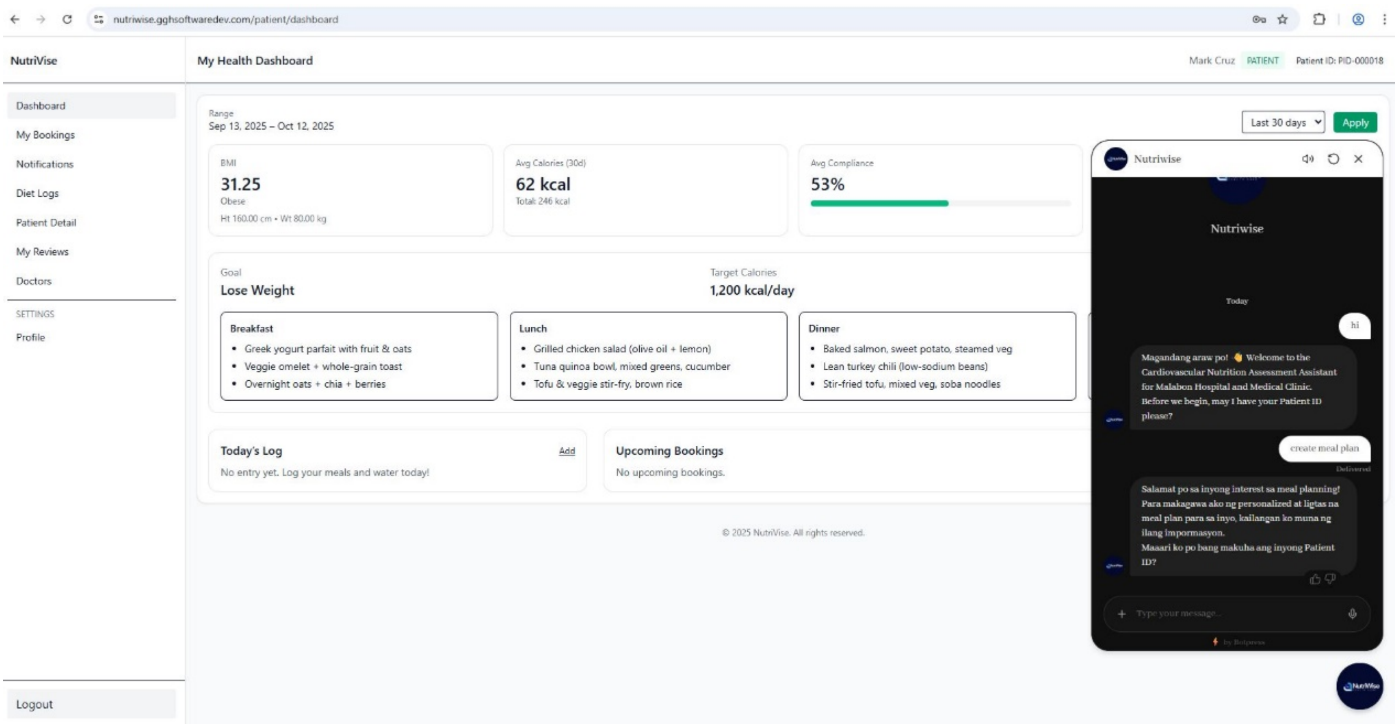

Figure 6. Chatbot Interaction.

The chatbot component enables natural language interaction between patients and the system. Patients can ask questions about their diet, receive nutritional advice, and get clarification on recommendations. An example of this interaction is shown in Figure 6, demonstrating the system's ability to understand and respond to patient queries in natural language.

5 Conclusion

This study introduced a Cardiovascular Patient's Nutrition Assessment Web Application with a Hybrid Recommender System tailored for Malabon Hospital and Medical Clinic. The project set out to address a practical need: helping patients and healthcare providers manage cardiovascular nutrition in a simple, reliable, and accessible way. By combining rule-based logic with intelligent recommendations, the system was able to generate personalized meal plans that align with patient health goals.

During testing with simulated data, the application performed well in terms of accuracy, speed, and system reliability. Core features such as registration, login, survey handling, and recommendation generation worked as intended and met the quality benchmarks set for the project. These results suggest that the application has strong potential to support clinicians and nutritionists in their work while also empowering patients to take an active role in managing their diet.

Looking ahead, the next step is to validate the system with real clinical data once ethics approval is secured. Feedback from both patients and healthcare professionals will be essential in refining the application and ensuring it fits seamlessly into real-world clinical settings. This project shows how technology can meaningfully contribute to healthcare by supporting better nutrition management and, ultimately, improved patient outcomes.

Data Availability Statement

Data will be made available on request.

Funding

This work was supported without any funding.

Conflicts of Interest

The authors declare no conflicts of interest.

AI Use Statement

The authors declare that no generative AI was used in the preparation of this manuscript.

Ethical Approval and Consent to Participate

This study was reviewed and approved by the Ethics Review Board of Philippine Women's University (ERB

Protocol Number: ERB2025_144). Written informed consent was obtained from all participants prior to data collection, in accordance with institutional guidelines and ethical standards for research involving human subjects.

All participants were informed of the purpose, procedures, potential risks, and benefits of the study, and were assured that their participation was voluntary. They were given the right to withdraw at any time without any consequences. Confidentiality and privacy of participants' information were maintained throughout the study, with all data anonymized and securely stored. Any results reported are presented in aggregate form to prevent identification of individual participants.

Special considerations were made to ensure cultural sensitivity and respect for local practices in nutrition and healthcare. The study adhered to ethical principles in line with international standards for research involving human subjects, ensuring that both patient care and professional guidelines were fully respected during the evaluation of the Patient Nutrition Assessment Web Application with Hybrid Recommender System.

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