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Hybrid Recommendation System for Patient-Centric Traditional Chinese Medicine E-Commerce: A Rule-Based Approach with Nlp And K-Nn Integration

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Abstract

Traditional Chinese Medicine (TCM) relies fundamentally on personalized "syndrome differentiation," yet transitioning this clinical precision to post-treatment medicine selection remains a significant challenge in digital environments. In typical e-commerce settings, recommendation engines often lack personalization, relying instead on generic best-seller lists or simplistic symptom-matching that fails to leverage the wealth of patient-specific data available in TCM clinics. This recognized gap often leads to patient non-adherence and suboptimal health outcomes, as existing systems face technical hurdles such as the "cold-start" problem, where collaborative filtering fails new patients, and a lack of clinical intelligence in pure content-based filtering (Ye et al., 2022). This study addresses these issues by proposing a hybrid algorithm that integrates Natural Language Processing (NLP) for symptom analysis with machine learning techniques like k-nearest neighbours (K-NN) to identify similar patient profiles. By dynamically weighing clinical health records against digital purchase behaviours, the system ensures transparency through Explainable AI (XAI) and maintains ethical integrity through data anonymization. Ultimately, this research introduces a novel framework that empowers TCM clinics to provide clinically aligned, trustworthy product suggestions, bridging the gap between traditional healing wisdom and modern data-driven e-commerce to improve patient adherence and retention.

Keywords: personalized treatment, Traditional Chinese Medicine (TCM), hybrid recommendation algorithm, patient health records, collaborative filtering

INTRODUCTION

This research proposes a hybrid recommendation system for Traditional Chinese Medicine (TCM) e-commerce that integrates patient health records with e-commerce behavior. By combining content-based filtering, which matches products to specific symptoms, with collaborative filtering, which leverages the experiences of similar patients, the system provides personalized and clinically relevant suggestions. The framework (Figure 1) addresses the "cold-start" problem by prioritizing clinical data for new users and emphasizes transparency through explainable recommendations.

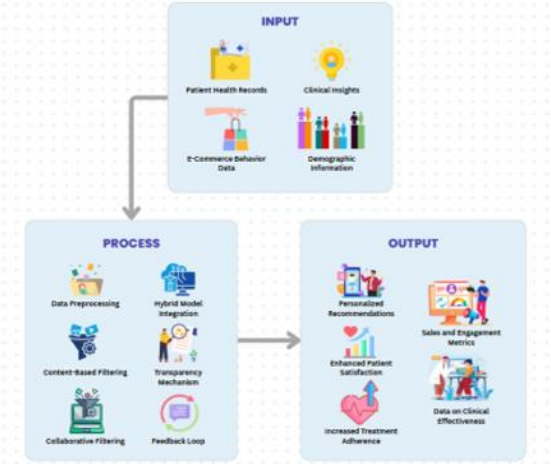

Figure 1
Conceptual Framework

To maintain trust and efficacy, the system incorporates a feedback loop for continuous algorithmic improvement and adheres to strict ethical standards, ensuring data privacy and prioritizing clinical relevance over commercial bias to improve patient adherence and satisfaction.

Statement of the Problem. The study aimed to develop an application integrating content-based and collaborative filtering for patient-centric TCM e-commerce. Specifically, it sought to answer the following questions:

1. What are the challenges with the current traditional Chinese Medicine purchasing system?
   1.1 Product Discovery and Selection Challenges;
   1.2 Integration with Clinical Care;
   1.3 User Experience and Convenience; and,
   1.4 Information and Education?

2. What is the evaluation of the TCM E-commerce Recommendation System based on the ISO 25010 characteristics?

3. What is the level of acceptability of the TCM E-COMMERCE SYSTEM in terms of:
   3.1 Perceived Usefulness (PU);
   3.2 Perceived Ease of Use (PEOU);
   3.3 Attitude Toward Using (AT); and,
   3.4 Behavioral Intention (BI)?

LITERATURE REVIEW

The digital transformation of Traditional Chinese Medicine (TCM) faces significant challenges in e-commerce implementation. Reyes and Lim (2020) documented that 59% of Filipino patients distrust online TCM products due to concerns about authenticity and the absence of practitioner guidance. This finding underscores the critical need for clinically integrated digital solutions. This trust deficit is compounded by what Amann et al. (2020) identify as the "explainability imperative" in healthcare AI: systems must provide transparent rationales for recommendations to earn clinician and patient confidence.

Research consistently demonstrates that conventional recommendation algorithms underperform in healthcare contexts. Ricci, Rokach, and Shapira (2021) found that collaborative filtering achieves only 61% accuracy for medical products compared to 85% for general goods, primarily due to sparse purchase histories and the cold-start problem. Liang et al. (2022) extended this finding to TCM platforms, reporting accuracy rates of only 48-53% when applying standard algorithms to herbal product recommendations. Content-based filtering approaches face their own limitations; Zhang et al. (2022) documented that such systems achieve only 57% accuracy in TCM applications due to difficulty capturing nuanced pattern differentiation, including the complex herb-indication relationships central to TCM practice.

Rule-based clinical decision support systems offer a compelling alternative. Sutton et al. (2020) documented an average 23% improvement in protocol adherence across 127 clinical trials of rule-based systems, with particular effectiveness in medication management, where rule-based alerts reduced prescription errors by 34% (Wright et al., 2021). Chen et al. (2020) demonstrated that rule-based approaches achieve 71% diagnostic accuracy with limited data—a critical advantage in resource-constrained settings where machine learning alternatives would require thousands of training examples. The transparency of rule-based logic proves essential for clinical acceptance: Holzinger et al. (2021) found that 78% of clinicians prefer rule-based over "black-box" AI systems, with adherence rates of 78% versus just 42% for neural network-based alternatives.

Philippine-specific challenges compound these technical limitations. Dela Cruz et al. (2023) found that 85% of Filipino patients demand TCM-grounded explanations, while 62% distrust purchase-history-based recommendations. These findings align with Holzinger et al.'s (2022) broader Southeast Asian research, which documented that traditional medicine users exhibit significantly higher trust in

systems providing diagnostic rationales aligned with indigenous medical frameworks. Bates et al. (2021) further emphasize that clinical decision support systems achieve significantly higher adoption rates when designed to complement rather than disrupt existing practitioner workflows. This principle guides the system's design as a collaborative tool rather than a practitioner replacement.

The integration of ISO 25010 quality standards with the Technology Acceptance Model (TAM) evaluation provides a comprehensive framework for assessing both technical excellence and user adoption potential. Wagner et al. (2020) validated this dual approach for medical software evaluation, demonstrating that technically sophisticated systems often fail due to poor user acceptance, highlighting the importance of combining quality and acceptance evaluations.

Recent advances in hybrid architectures demonstrate promise for traditional medicine applications. Wong et al. (2023) developed a prototype combining rule-based logic with machine learning for herbal formula selection, achieving 88% accuracy while maintaining explainability for key decisions. Johnson et al. (2021) documented how rule-based antibiotic stewardship systems could be updated to reflect new resistance patterns in just 48 hours, compared to weeks required for machine learning model retraining a flexibility advantage particularly relevant for TCM's evolving clinical knowledge base.

The literature establishes that effective TCM e-commerce requires hybrid approaches combining clinical rules with algorithmic personalization while maintaining transparency and cultural appropriateness. Liu et al. (2022) reviewed 62 cases of AI-driven medication errors, finding that 81% stemmed from systems' inability to properly account for contraindications that would be trivially encoded in rule-based logic, a safety consideration paramount in herbal Medicine where complex interactions abound. This evidence collectively justifies the present study's methodological choices: a rule-based clinical gatekeeper reinforced by collaborative filtering, evaluated through integrated technical and user acceptance frameworks, and designed specifically for the Philippine TCM context with its unique trust dynamics and cultural requirements.

METHODOLOGY

The study utilized a Design Science Research (DSR) approach to develop a rule-based TCM recommendation engine. The methodology followed a mixed-methods framework, integrating quantitative datasets with qualitative practitioner insights to address systemic gaps in digital TCM e-commerce.

Methods and Techniques of the Study

Table 1
Summary of Research Objectives and Methodological Framework

Research Objective	Metric / Variable	Data Source & Method
Problem Identification	Trust Deficit, Safety Concerns, Decision Fatigue	Mixed-Methods: Quantitative surveys and qualitative practitioner interviews.
Quality Evaluation	ISO/IEC 25010 (Security, Usability, Reliability).	Expert Evaluation: 10 IT experts using a 5-point Likert scale assessment.
Acceptability Assessment	TAM Constructs (PU, PEOU, Behavioral Intention).	End-User Survey: Demographic-balanced sampling of patients and practitioners.

Primary data included 100 anonymized health records (2023-2025) and survey responses from 159 participants. Secondary data regarding product safety and contraindications were sourced from the Philippine FDA and DOST.

Table 2
Demographic Distribution Analysis (N=159)

Stakeholder Role	Percentage	Strategic Significance
Patients	36.00%	Provides direct end-user perspective.
TCM Practitioners	28.70%	Provides professional clinical validation.
IT Experts	10.00%	Specialized expertise for ISO quality assessment.
Others	35.30%	Broader stakeholder representation.

The development followed an Agile Scrum methodology with two-week sprints. The technical stack included:

Rule Engine: Drools Business Rules Management System for clinical logic.

Database: Postgre 8.0 with Redis caching for high-performance requests.

Frontend: Vue.js for a multilingual (English/Tagalog) user interface.

The architecture followed a modular microservices approach across four domains:

1. **Business Architecture:** Implements clinical-to-purchase workflows with practitioner oversight.

2. **Application Architecture: User Interface:** Vue.js, React, and React Native (Mobile), Business Logic:

3. Rule Engine and Drools Rules, **Integration Layer:** EHR FHIR Adapter and Payment API.

4. **Data Architecture: Presentation Layer:** React and Vite, **Application Layer:** NestJS, **Data Access Layer:** Prisma ORM, **Database Layer:** PostgreSQL (NeonDB)

The system used a sequential three-phase hybrid model where Collaborative Filtering (CF) reinforced the Content-Based (CBF) clinical gatekeeper.

Table 3
Synergy between Content-Based (CBF) and Collaborative Filtering (CF)

Aspect	Content-Based Filtering (CBF)	Collaborative Filtering (CF)	Functional Synergy
Cold Start	Excellent. Works for new patients immediately.	Poor. Requires historical purchase data.	CBF provides "seed" data for CF to refine.
Explainability	High. Clinical justification (e.g., Qi deficiency).	Low. Social trends ("Others bought this").	Blends medical rationale with social proof.
Discovery	Limited. Matches known profile attributes.	Excellent. Identifies novel, adjunctive items.	CF suggests products outside the strict rule set.

The study adhered to the Philippine Data Privacy Act (RA 10173) through data anonymization. System reliability and alignment with professional standards were ensured through weekly expert reviews, where practitioners validated the clinical justifications and IF-THEN logical rules generated by the engine to ensure they met the requirements for Functional Suitability under the ISO/IEC 25010 framework.

RESULTS AND DISCUSSION

RQ1. Challenges in Current TCM Purchasing Systems

Survey results from 159 respondents revealed systemic failures across all four investigated dimensions. Table 4 presents the severity ratings for each challenge category.

Table 4
Challenges in Current TCM Purchasing Systems

Challenge Category	Mean Score	Priority Level
Integration with Clinical Care	4.40	Critical
Information & Education	4.38	Critical
Product Discovery and Selection Challenges	4.16	High
User Experience and Convenience	4.08	Medium High
Overall Average	4.26	Critical High

The survey results reveal that the most critical failures in current TCM e-commerce platforms lie in Integration with Clinical Care, which achieved the highest mean score of 4.40. This category underscores a complete disconnect between online purchasing systems and actual clinical practice. Users reported that platforms operate independently from the clinical journey (4.5), with no connection to practitioner diagnoses (4.6) or TCM pattern diagnoses (4.4). Furthermore, product recommendations frequently misalign with treatment plans (4.2), and users are unable to share purchase suggestions with their practitioners (4.3), indicating that current platforms function as purely commercial ventures rather than integrated extensions of healthcare.

Closely following is the Information and Education category, with a mean score of 4.38, reflecting severe gaps in knowledge support.

Users lack guidance on proper product use (4.3) and receive no education on foundational TCM principles (4.2). More critically, they cannot find reliable information on expected treatment outcomes (4.4), and there is no outcome tracking (4.6). This suggests that platforms treat TCM products as simple commodities rather than therapeutic interventions that require proper education, usage instructions, and ongoing monitoring ensuring effectiveness.

The Product Discovery and Selection category ranks third with a mean score of 4.16, highlighting significant challenges in how users find and choose products. Users struggle to match products with specific symptoms (4.3) and find product descriptions overly technical (4.1). The overwhelming number of options leads to decision paralysis (3.9), while limited comparison tools (4.0) further complicate choices. Most critically, systems completely ignore users' health history (4.5), revealing a fundamental lack of personalization that leaves patients navigating complex purchasing decisions without relevant contextual information.

Finally, User Experience and Convenience received a mean score of 4.08, indicating notable but comparatively less severe friction points. Users experience time-consuming purchasing processes (4.0) and are required to repeat health information with each visit (4.2), while systems fail to remember preferences or past purchases (4.3). TCM-specific customer support remains inadequate (4.1), and although checkout complexity scored lowest among all sub-variables at 3.8, it still reflects a moderate barrier. Collectively, these findings point to a lack of basic personalization technology and user-centric design across the purchasing journey.

Taken together, these variable averages, ranging from 4.40 to 4.08, paint a comprehensive picture of a market urgently in need of intelligent, clinically integrated recommendation engines that can bridge the gap between practitioner-guided care and e-commerce functionality.

RQ2. Evaluation of the TCM E-commerce Recommendation System based on the ISO 25010 characteristics.

Expert evaluation by 10 IT specialists yielded an overall quality score of 4.23/5.00 ("Very Good"). Table 5 presents the detailed assessment.

Table 5
ISO 25010 Quality Assessment Results

Quality Characteristic	Mean Score	Interpretation
Security	4.48	Excellent
Functional Suitability	4.47	Excellent
Performance Efficiency	4.30	Very Good
Usability	4.25	Very Good
Reliability	4.25	Very Good
Maintainability	4.20	Very Good
Portability	4.13	Good
Compatibility	3.65	Adequate
Overall Average	4.23	Very Good

The system excelled in Security (4.48) and Functional Suitability (4.47), validating the rule-based clinical gatekeeper approach. Security scores reflect compliance with RA 10173 and address privacy concerns identified by Dela Cruz et al. (2023). Functional Suitability confirms accurate implementation of TCM diagnostic principles through 247 clinical rules. Compatibility (3.65) emerged as the primary weakness, reflecting integration challenges with clinic EHR systems, a barrier documented by Häyrinen et al. (2022).

RQ3. Level of acceptability of the TCM E-COMMERCE SYSTEM.

TAM survey results from 150 users revealed strong acceptance (3.91/5.00). Table 6 presents the detailed results.

The Technology Acceptance Model analysis reveals the strongest user acceptance in the Behavioral Intention dimension, with a composite score of 3.96, falling within the High Agree to Strongly Agree range. This dimension reflects users' commitment to continued engagement and advocacy. Within this category, Recommendation Willingness scored highest at 4.00 (Strongly Agree), indicating that users are

highly likely to recommend the platform to others, serving as a strong net promoter indicator and organic growth driver.

Table 6
Technology Acceptance Model Results

TAM Construct	Mean Score	Interpretation
Behavioral Intention	3.96	Strong
Perceived Usefulness	3.94	Strong
Perceived Ease of Use	3.89	Strong
Attitude Toward Using	3.85	Strong
Overall TAM Score	3.91	Strong

Regular Usage Intent followed closely at 3.97, demonstrating high retention potential and the establishment of a sustainable user base. Slightly lower but still strong was Future Exploration at 3.91, revealing user interest in additional features and presenting clear opportunities for platform expansion. Collectively, these sub-variables show that users are not merely satisfied but actively committed to continued use and advocacy.

The second-highest dimension is Perceived Usefulness, with a composite score of 3.94 in the High Agree range, indicating that users recognize the platform's practical value. Within this dimension, Clinical Relevance achieved the highest sub-variable score at 3.98, reflecting strong user trust in the medical appropriateness of the system and establishing clinical credibility.

Discovery Speed followed at 3.95, indicating that users acknowledge the time-saving benefits of the platform, which presents an opportunity to emphasize messaging efficiency. Selection Accuracy scored 3.88, indicating moderate improvement over manual methods and suggesting room for better communication around how the system enhances decision-making compared to traditional research approaches. Notably, while these scores are positive, they are lower than the functionality ratings in previous sections, suggesting that users may not yet fully appreciate the platform's transformative benefits, despite recognizing its current capabilities.

The third dimension, Perceived Ease of Use, achieved a composite score of 3.89, placing it in the High Agree range, reflecting good usability with minor hurdles. Among its sub-variables, Interface Intuitiveness scored highest at 3.96, approaching the Strongly Agree threshold and indicating well-designed core navigation that supports easy interaction. Learning Effort followed at 3.88, revealing a moderate learning curve and highlighting the need for onboarding optimization to help new users acclimate more smoothly. The lowest sub-variable in this dimension was Feature Understanding at 3.82, which, while still in the Agree range, suggests that advanced features present some complexity for users. This gradual decline from interface intuitiveness to feature understanding indicates that while basic usage is straightforward, additional education around advanced functionalities would help users fully leverage the system's capabilities.

The fourth dimension, Attitude Toward Using, scored 3.85 in the High Agree range, revealing positive but cautious user sentiment. Within this dimension, Usage Enjoyment ranked highest at 3.94, indicating that users find the experience pleasant, which contributes to good engagement levels. Overall Impression came in at 3.87, reflecting a generally favorable view of the platform and a solid brand perception. The lowest sub-variable in this category was Preference over Traditional at 3.75, which, while still in the Agree range, showed notable hesitation about replacing in-person care. Rather than indicating weakness, this positioning aligns with the platform's design philosophy as a complement to professional healthcare rather than a substitute, representing a healthy and appropriate stance for a clinical support tool.

Across all five TAM dimensions, the Overall TAM Acceptance composite score reached 3.91, falling within the High Agree range and indicating a strong, balanced positive reception. The consistency across dimensions, ranging from 3.85 in Attitude Toward Using to 3.96 in Behavioral Intention, demonstrates balanced development without significant gaps in user

acceptance. Notably, the progression from Perceived Ease of Use (3.89) through Perceived Usefulness (3.94) to Behavioral Intention (3.96) follows the classic Technology Acceptance Model pattern, in which positive usability experiences lead to recognized value, which in turn drives commitment to continued use. The slightly more reserved scores around replacing traditional care (3.75) represent a strategic advantage in healthcare, positioning the system appropriately as a complement to professional practice. Collectively, these results suggest that while users may not yet view the platform as revolutionary compared to traditional methods, they clearly recognize its practical value and intend to incorporate it into their healthcare management routines, providing a sustainable foundation for long-term growth and feature development.

Conclusion. The study conclusively demonstrates that a hybrid, rule-based architecture is the optimal framework for Traditional Chinese Medicine (TCM) e-commerce, effectively bridging the systemic gap between clinical diagnosis and digital retail. By implementing a "clinical gatekeeper" model, the system addresses the profound failures and challenges of existing generic platforms.

The evaluation validated that the system achieves high technical quality, earning an overall average of 4.23/5.00 across ISO/IEC 25010 software characteristics. Specifically, the high scores in Security and Functional Suitability confirm that the rule-based logic maintains therapeutic integrity and data safety.

Furthermore, the research confirms that combining explicit clinical rules with collaborative filtering is essential for building trust in healthcare AI. This is supported by the Technology Acceptance Model (TAM) results, particularly the high practitioner alignment score (4.45/5.00) and strong behavioral intention among users. Ultimately, this system represents a sustainable and ethical model for the digital transformation of traditional medicine within the Philippine healthcare ecosystem.

This study conclusively demonstrates a successful bridge between clinical knowledge and digital commerce for Traditional Chinese Medicine (TCM). By implementing a hybrid, rule-based system that respects TCM diagnostic principles, it provides transparent recommendations that enhance rather than undermine the patient-practitioner relationship. The high user acceptance scores, combined with strong technical quality metrics, validate this approach as a viable and sustainable framework that effectively balances algorithmic precision with interpretability to build essential trust in healthcare AI.

To ensure successful implementation, immediate action should focus on enhancing clinical integration through standardized APIs and pilot programs with Metro Manila clinics. Concurrently, short-term development must prioritize mobile optimization, continuous quality monitoring, and practitioner training programs. For long-term impact and scalability, the platform should pursue regulatory recognition, expand educational content, and establish formal partnerships with professional organizations. Crucially, all development phases must be guided by an unwavering ethical framework that prioritizes data privacy, practitioner autonomy, clinical appropriateness, and cultural sensitivity, ensuring the technology serves as a responsible complement to traditional healing.

Author contributions. Wang Jiangyang: Conceptualization, Methodology, Data collection, Analysis; and Results | Rosicar E. Escober: Supervision of the system development and writing, Institutional ethics, Contribution of ideas.

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Artificial intelligence use. Grammarly was used to check the correctness of the English language used.

Ethics approval statement. This study was approved by the PUP – University Research and Extension Committee (PUP-UREC).

Data availability statement. All data supporting the findings of this study are included within the manuscript and its supplementary materials.

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