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Original Article

Research on Improved Design Method of Intelligent Pharmacy Based on KANO/AHP/QFD and FBS Modeling

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ABSTRACT

Aim/Background: The use of Intelligent pharmacy applications has grown increasingly popular in the field of intelligent healthcare. The objective of this study is to develop an Intelligent pharmacy that addresses the issues of user inconvenience and low satisfaction by meeting their specific requirements. At the same time, it offers a benchmark solution for an intelligent medication management system. **Materials and Methods:** This study employs the KANO model, AHP, QFD and FBS model to study the design elements and structure of an Intelligent pharmacy, based on user interviews, literature research and questionnaire research. The improved design of Intelligent pharmacy was finalized with this design methodology. An assessment of the improved Intelligent pharmacy was also carried out by the user. **Results and Discussion:** The ranked order of importance of user needs was functionality, interaction and appearance. The translated design elements were assisting the pharmacist's work, appearance suitable for hospitals, intelligent drug management, friendly interface and reasonable human-machine dimensions. The design method is extremely effective for developing Intelligent pharmacy and can offer innovative concepts and sources of inspiration for other intelligent medical items.

Keywords: Intelligent Pharmacy, KANO modelling, Analytic Hierarchy Process, Quality Function Deployment, Functional Behavior Structure, Improved Design.

INTRODUCTION

The development of global smart healthcare has led to the widespread adoption of more efficient and expedient healthcare services, which have been highly appreciated by healthcare professionals.[1] Drug management is intricately linked to patient treatment and an accurate and efficient medication procedure not only alleviates the burden on pharmacists but also decreases the occurrence of drug dispensing errors.[2] The management of drugs is crucial for the safety and effectiveness of patients' healthcare. Standardized drug management plays an essential part in clinical care.[3] Over the past few years, the use of automated equipment, like completely automated electronic medicine cabinets, has enhanced the effectiveness of hospital pharmacies and decreased prescription errors.[4] The implementation of Intelligent pharmacy can enhance dispensing efficiency significantly, resulting in cost savings on worker costs.[5] Simultaneously, it has the ability to adaptively allocate resources, enhance the efficiency of drug retrieval and decrease the workload of pharmacists.[6] Intelligent pharmacy may efficiently reduce storage time despite the complexity of drug information and the enormous store volume.[7] Furthermore, when compared to the conventional dispensing approach, it enhances the efficiency of dispensing while simultaneously reducing operational expenses and the required pharmacy space.[8]

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The existing user experience of Intelligent pharmacy in the market is currently unsatisfactory. The primary emphasis of the Intelligent pharmacy design in the market is on its functionality, with limited exploration of other usage requirements of pharmacists. The design decision-making process of Intelligent pharmacy does not involve the active engagement of key user pharmacists, leading to a lack of applicability in the product.[2] Pharmacists in the medical area possess a specialized knowledge and have distinct requirements for products. Hence, it is imperative to integrate sufficient attention to the well-being of pharmacists into the development of Intelligent pharmacy. The crux of Intelligent pharmacy design lies in meeting the requirements of pharmacists and enhancing Intelligent pharmacy can be achieved by precisely identifying and measuring the unique design aspects that cater to pharmacists' demands.

This study aims to gather and examine the user requirements from the perspective of pharmacists, utilizing the KANO model.

Additionally, it seeks to quantify and analyze the importance of these user requirements from the perspective of designers, employing the AHP model. The integration of the KANO model and Analytic Hierarchy Process (AHP) models allows for the collection, analysis and categorization of user requirements from both the perspectives of pharmacists and designers. These requirements can then be converted into product design elements using the Quality Function Deployment (QFD) model, which provides guidance for the design process. Additionally, the use of scenario state analysis, in conjunction with the FBS model, enables a more precise design analysis and the creation of objective and specific design guidance, resulting in a well-structured design. The Functional Behavior Structure (FBS) model offers enhanced precision in design analysis and translates it into objective and precise design direction for constructing a rational structural design. The integration of these four elements can offer a novel scientific approach to enhance the user experience and user satisfaction of Intelligent pharmacy.

THEORETICAL RESEARCH AND ANALYSIS

Literature Review

KANO model

The KANO model, as proposed by Kano,[9] a Japanese authority on quality management, assists in ascertaining whether a service or product satisfies the requirements of the consumer. This metric is employed to assess the correlation between service quality and user satisfaction. It is a qualitative analysis paradigm with two dimensions that classify the attributes of products and services.[10] The precise methodology entails gathering user requirements via a two-factor survey.[11] Following this, the user's requirements are categorized into the following five groups using the KANO evaluation table: fundamental needs (M), anticipated needs (O), Allure needs (A), undifferentiated needs (I) and inverse needs (R). The product design should prioritize addressing the user demands outlined in categories M and O. Subsequently, the requirements of category A should be investigated. Qualitative analysis can be employed to ascertain the pivotal factors that influence user satisfaction using the KANO model.[12] The user's needs were identified through a combination of literature review and user interviews. The two-factor questionnaire was utilized to classify each demand; the questionnaire will contain the attribute position of the value sum, which represents the proportion of the user's needs that most significantly alter the characteristics of the product. To prevent reverse demand in product development, it is essential to satisfy the user's fundamental requirements before addressing their expectations and desire for excitement. Yu Zhe Qi and other scholars extracted design elements such as colour, shape and pattern using the KANO model of emotional engineering research methods and incorporated them into the design of golf implement head sculptures.[13] Using the KANO model, XIANG-LI LUO and others categorized and ordered product feature requirements according to the attributes of health protection products intended for the elderly.[14] They also outlined three primary design approaches for the interaction interface. In conclusion, the KANO model is capable of classifying and analyzing absolute user requirements from the user's perspective. This can assist designers in comprehending the requirements of the user.

Analytic Hierarchy Process

The AHP model, which integrates qualitative and quantitative analysis, was initially introduced by Professor A.L. Saaty, an operations researcher from the United States.[15] The AHP method is primarily utilized in system analysis to address multi-objective decision-making challenges. It accomplishes this by decomposing the intricate problem into distinct layers: goals, criteria and programmes. The solution layer comprises numerous alternative solutions, while the criterion layer comprises diverse criteria for assessing and contrasting solutions. The objective layer symbolizes the overarching aim of the decision-making process. The outcomes of user requirements research can be quantified using AHP, which employs two-by-two comparisons of evaluation indicators conducted by experts. Each user requirement's level of importance is symbolized by another user requirement.[16] Where element C_{ij} denotes component C_i and element C_j's importance level description is relative to element A for the two-by-two comparison. By weighting the requirements according to a criterion scale (Appendix 1),[17] the level of importance attributed to each user requirement is determined.

The weights of the indicators are computed after constructing the judgement matrix, using the formula delineated below.

(1) Add the elements of the matrix.

$$\overline{w_\imath} = \sum_{j=1}^{n} \overline{a_{\imath\jmath}} (\mathrm{i.j} = 1\ ,\ 2\ ,\ \ldots\ldots \mathrm{n})$$

(2) Implement regularization for $(\overline{w_\imath})$ in the above equation, where w_i is the weight of the i the indicator.

$$w_i = \overline{w_\imath} / \sum_{i=1}^{n} \overline{w_\imath} (\mathrm{i} = 1\ ,\ 2\ ,\ \ldots\ldots \mathrm{n})$$

(3) Calculate the maximum Eigen value of the judgment matrix A

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(Aw)_i}{w_i}$$

Where n is the order of the matrix, A is the judgment matrix, w_i is the weight of the i to indicator. $\lambda_{\max}$ is the maximum Eigen value of the judgment matrix A.[18]

(4) Consistent numerical CR solving.

$$CI = \frac{\lambda - \mathrm{n}}{n - 1}$$

$$CR = \frac{\mathrm{CI}}{RI}$$

The test satisfies the criteria when CR is less than 0.1; this indicates that the evaluation satisfies the consistency test.

At present, numerous academics employ the AHP model in their investigations. Liu, Wei,[19] and other scholars employed the AHP method to assess the design elements, thereby enhancing the objectivity and rigor of product design. As an exercise, they developed a medical product for treating rhinitis at home. 'Understanding Design' is a liberal arts course that Kim Jun Yon developed utilizing the AHP model to assess its significance and assist instructors in better organizing design courses.[20] Hyun Cho *et al.*[19] investigated the effects of illumination and perspective factors on the three-dimensionality of game objects using the AHP model. In conclusion, AHP can support designers in delivering robust decision support in an efficient manner.

Quality Function Deployment

Quality management systems employ the deductive analysis technique known as QFD. Yoji Akao and Shigeru Mizuno, two Japanese scholars, conceived and advanced the concept. To aid designers with subsequent designs, QFD is utilized in product design to convert user requirements into design elements and rank the significance of these elements. User requirements and design elements are matched exactly when QFD is implemented. The QFD model subsequently examines any conflicts that may arise between design elements and the correlation between individual user requirements and design elements. The design elements are subsequently evaluated quantitatively. Bergquist, K. and other researchers have utilized the QFD model to transform user requirements into product features during product development. As an illustration of design practice, safety shoe design was guided by this model. Gerson Tontini[21] suggested integrating the Kano model and QFD model, evaluating their respective shortcomings and substantiating the viability of the Kano-QFD model through the enhanced design of a draft beer cup. Buakum and Dollaya[22] designed a temperature-controlled medicine pouch that satisfies the requirements of the clientele using the AHP-QFD model. User requirements were gathered using the model and subsequently converted into technical specifications, which served as the foundation for product design. The resultant product successfully fulfilled the specifications of the users and attained an acceptable standard of excellence. User requirements are effectively translated into product design elements using the QFD model. This aids designers in comprehending user requirements and fulfilling them throughout the product development process.

Functional Behavior Structure

Functional Behavior Structure (FBS) represents a mapping transformation between Structure (S), behavior (F) and function (B).[23] This process enables designers to create products by establishing a correspondence between structural and functional components. The process of mapping converts functional elements into anticipated user behaviors. The process of behavior-structure mapping entails the conversion of anticipated behaviour into the specific configuration of a product. Ma, Dongming,[23] and other scholars analyzed the requirements of users living alone using the FBS model. The 'function-behavior-structure' mapping was utilized to delineate the corresponding product structure and the resulting model was implemented to enhance the design of kitchen appliances. By integrating QFD and the Fuzzy-Based System (FBS) model, Yang Xinyan and other researchers examined the correlation between the requirements of real and hypothetical user groups in order to develop product functions.[24] They verified design practice using the development of rehabilitation products and concluded that the model is scientific and has the potential to enhance the quality of product design. The FBS model can assist designers in more thoroughly and methodically comprehending and managing the functional structure of complex systems, thus enhancing the design's quality and efficiency.

Research Processes

KANO, AHP, QFD and FBS are extensively utilized in the design field. Hence, the KANO model and AHP model are employed to comprehensively investigate and structure the genuine requirements of consumers. Utilizing the QFD paradigm to convert user needs into specific design elements and provide guidance for the design process. The FBS model is utilized to conduct design analysis of the Intelligent pharmacy structure and convert it into precise and targeted design recommendations in order to address the issue of excessive subjectivity and limited adaptability in the design process. The integration of KANO, AHP, QFD and FBS models offers a systematic approach to enhance product design and foster innovation. By combining the KANO model, AHP model, QFD model and FBS model, it is possible to effectively identify the requirements of pharmacist users when using Intelligent pharmacy. These requirements can then be translated into product elements and used to design a well-structured system that offers more accurate and scientifically-guided design decisions.

In the user requirement identification stage, user requirements are extracted through user interviews and the organized user requirements are analyzed qualitatively by the KANO model and then analyzed quantitatively by the AHP model and assigned weights. In the design element determination stage, the QFD quality house model is used to accurately map the user requirements to the product design elements, so that the designers can comprehensively measure the priority order among the design elements to accurately guide the subsequent design. In the design structure design stage, the functional design elements are partially imported into the FBS model to determine the specific expected user behaviors based on the functional requirements and then the reasonable user behaviors are transformed into the specific structure of the product to provide designers with innovative design ideas. The specific design process is shown in Figure 1.

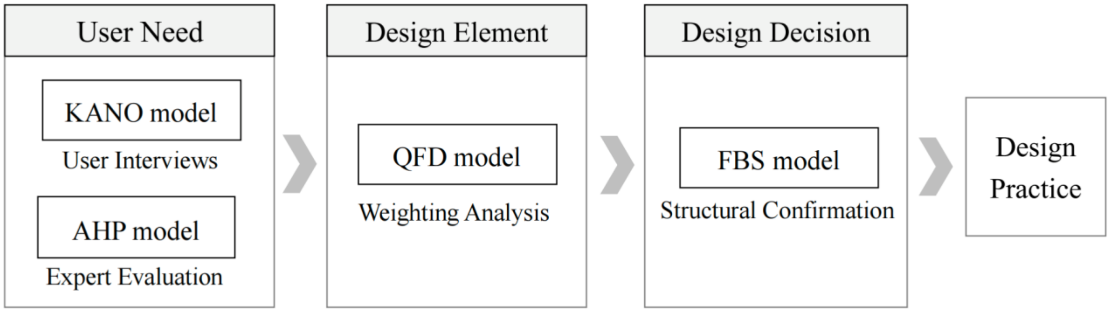


Figure 1: Research Flowchart.

OBTAINING OPTIMIZED DESIGN ELEMENTS BASED ON KANO/AHP/QFD

Identifying user requirement

This study collects and summarizes the user needs of Intelligent pharmacy by conducting user interviews with pharmacists (Appendix 2) and researching related literature and reports. In order to extract the user requirements elements and construct the Intelligent pharmacy User Requirements Elements Indicator System (Table 1).

Segmentation of User Requirements Using the KANO Model

The KANO questionnaire, comprising both positive and negative items, was developed on the basis of the identified user requirements for Intelligent pharmacy. A total of 50 questionnaires were distributed to hospital pharmacists to determine the personnel for this research project. After screening for incomplete questionnaires, questionnaires completed in an insufficient amount of time and reverse questions answered incorrectly, 46 valid questionnaires were obtained, representing a 92% valid questionnaire rate. The demographic data are presented in Appendix 2, while the valid questionnaires were subjected to reliability analysis using SPSS. The resulting Cronbach's alpha value was 0.74, indicating acceptable reliability. The questionnaire items were also reviewed by experts in the field (see Appendix 3) to ensure the questionnaire's validity.

The recovered valid questionnaires are subjected to analysis, with each user requirement element quantified in accordance with the KANO model for user requirement classification. This enables the derivation of values for A, O, M, I, R and Q for each requirement, as well as the comparison of the magnitude of each value. The attribute attributed to a user requirement is identified as the one with the largest sum. The user requirement attributes are presented in Table 2.

An inventory of user requirement attributes is produced by calculating the average value of contentment and discontentment (Table 2). Based on the analysis of the calculation outcomes and the functional attribute distribution depicted in the two-dimensional quadrant diagram, it is evident that requirements C2, C4, C10, C11 and C14 are considered fundamental. C18, C3, C5, C7, C12, C13 and C15 are all considered desirable necessities. C6, C8, C9, C12 and C18 are all considered to be charismatic requirements. Undifferentiated requirements (C1). Based on the analysis of the user questionnaire, it can be inferred that prioritizing the fulfillment of fundamental needs is crucial for the design process, with desired needs and charismatic needs following suit.

User Specifications Analysis of Weighting Utilising AHP Modelling

The AHP hierarchical analysis method is employed for the purpose of evaluating the relative importance of each user requirement and subsequently determining the weighting assigned to each. A comprehensive and objective user demand is constructed from the perspective of the designer. This demand is initially divided into three layers: user demand layer A, demand category layer B and specific demand layer C. These layers are presented in Table 3. Subsequently, a judgment matrix is constructed and seven experts in product design, intelligent medical care and improved design are invited, as per the user demand study. Of these experts, four are from academic institutions and three are from industry. One of the experts had a minimum of five years of experience in research related to Intelligent pharmacy and had recently utilized Intelligent pharmacy products. This was done to ensure that the invited experts had the requisite proficiency and knowledge for Intelligent pharmacy. The experts' information is presented in Appendix 2. The scoring was based on a nine-level quantitative method and the scores were averaged and solved by applying the weights of each level. A consistency test was performed on the matrix scoring. The test yielded a CR value of less than 0.1 for each level, thereby passing the consistency test. Subsequently, the comprehensive weights of each demand indicator were calculated and ranked, as illustrated in Table 4.

Design element acquisition using QFD modeling

The QFD model is employed to transform user requirements into design elements, which can be defined as the psychological expectations of users of a given product. The design elements can be regarded as the modifications implemented by the designer to satisfy the users' psychological expectations. A group discussion was employed to transform user requirements into design

Table 1: Ranking and combined weights of demand indicators.

Levels of demand guidelines	Secondary prerequisites directives	Explanation in detail of the requirements
Modeling B1	Simple appearance C1	Simple and beautiful styling.
	Easy to clean C2	Designed for easy cleaning and sanitizing.
	Calm color C3	Colors help pharmacists do their job.
Function B2	Medication reminder C4	The pharmacist after dispensing, prompting the pharmacist to pick up the medication.
	Reasonable design of the discharge port C5	The medication collection area is well-designed and makes it easy for the pharmacist to collect medications.
	Machine recognized dispensing form C6	Automated machine dispensing reduces manual errors.
	Rapid dispensing C7	Fast dispensing time and high efficiency.
	Fast drug identification when storing medicines C8	Drug storage is faster due to the high accuracy of storage.
	Intelligent storage of medicines C9	Provide real-time drug inventory information to help pharmacists streamline drug purchasing.
	Easy maintenance C10	Fast feedback on repairs and timely arrival of service personnel for maintenance.
	Reasonable man-machine dimensions C11	Ergonomically designed for pharmacist use.
	Statistics on the use of medicines C12	I Summarize the status of drug use in the pharmacy.
Interaction B3	Expired medicine alert C13	Expired medications provide clues.
	Clear and easy to understand interface information C14	The interface information is clear and easy to understand.
	Provide manual assistance when necessary C15	Able to provide manual assistance when problems arise.
	Electronic prescription display C16	Provide e-prescribing to make it easy for pharmacists to view and confirm medication information.
	Show drug interaction alerts C17	Automatically check for drug interactions to improve the safety and rationality of prescriptions.
	Drug utilization analysis and optimization C18	Analyze drug utilization and provide optimization and service improvements to improve overall pharmacy operational efficiency.

elements, as illustrated in Figure 2. Subsequently, seven experts (see Appendix 2) were invited to score the correlation between user requirements and design elements, with irrelevant items assigned a value of 0, weak correlations a value of 1, medium correlations a value of 3 and strong correlations a value of 5. By transforming user requirements into design features and analyzing their correlation, it is possible to consider each user requirement with greater scientific and objective precision, thereby identifying the priority of design elements in a manner that improves user experience. In this model, user requirements are represented by the letter M and design elements by Y. The design requirement quality house for Intelligent pharmacy is presented in Table 4.

Finally, the relative weights are solved by using E_j to denote the absolute importance weight of the design requirement D, e_j denote the relative importance weight, W_i to be the weight of the i th user's requirement and F_{ij} to be the value of the relationship corresponding to the two.

(6) Design Requirements (D) Weighting Formulas:

$$\sum_{i=1}^{n} W_i \times F_{ij}(\mathrm{i}\ ,\ \mathrm{j} = 1,2,\ldots\ldots,\mathrm{n}) = E_j$$

(7) Formula for calculating the relative importance weights of design requirements:

$$\frac{E_j}{\sum_{j=1}^{n} E_j}(j = 1,2,\ldots\ldots,n) = e_j$$

After normalizing the design elements (see Appendix 4), we found that the first important one is Y7, the second important one is Y1, the third important one is Y5 and then the order is

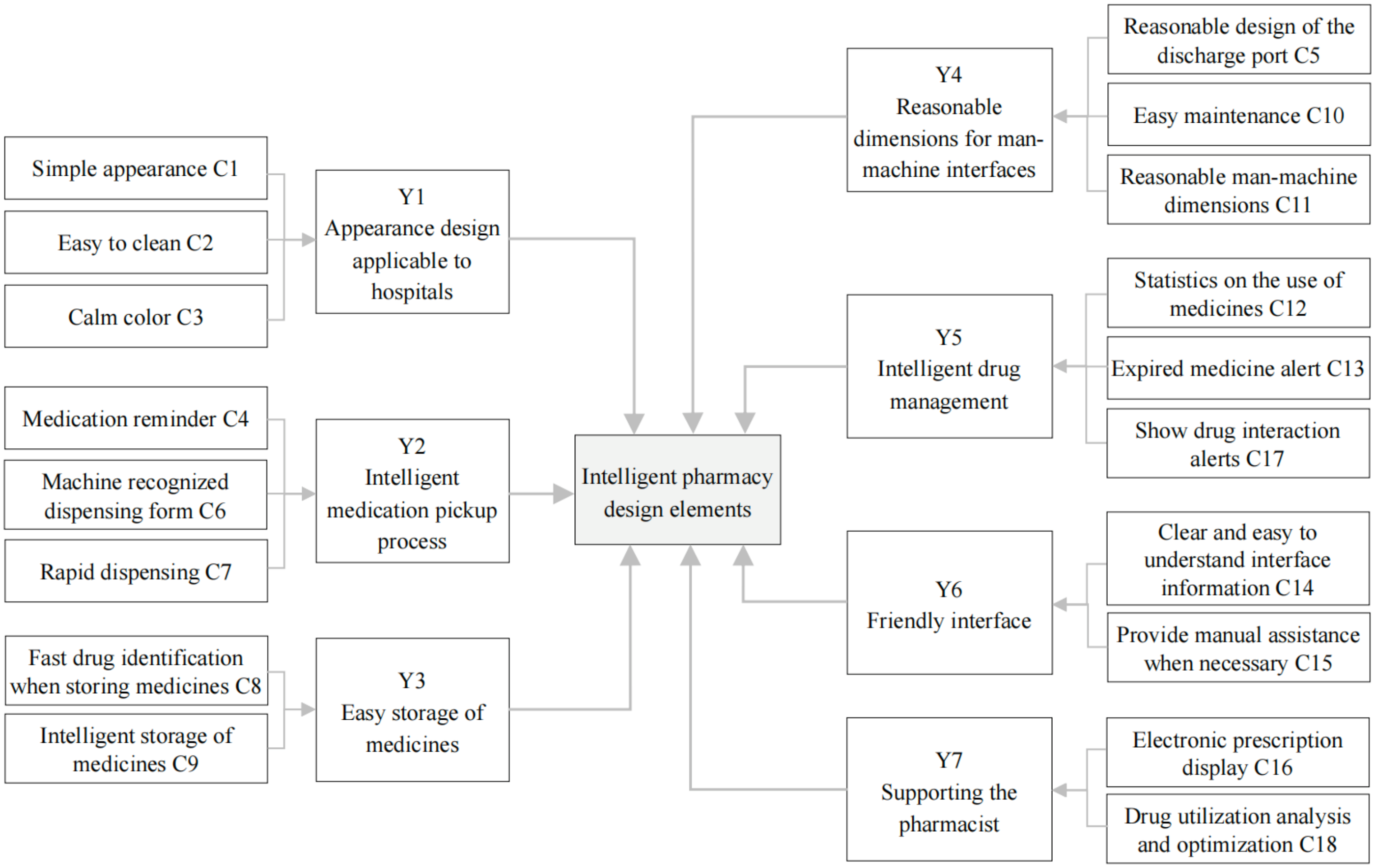


Figure 2: Matching Table of User Requirements and Design Elements.

Table 2: Attributes of each user requirement.

user requirement	A (%)	O (%)	M (%)	I (%)	R (%)	Causality
C1	4.7	9.1	31.5	43.4	11.3	I
C2	18.6	14.5	52.7	7.5	6.7	M
C3	10.9	38.5	19.5	17.7	13.4	O
C4	7.0	21.3	62.3	4.5	4.9	M
C5	23.2	49.8	19.7	5.4	1.9	O
C6	59.2	19.2	10.3	6.8	4.5	A
C7	24.1	52.6	16.4	3.6	3.3	O
C8	49..0	21.5	20.6	4.6	4.3	A
C9	44.5	19.6	20.3	6.9	8.7	A
C10	21.0	17.3	48.6	7.6	5.5	M
C11	16.8	51.0	17.9	6.4	7.9	O
C12	51.4	17.9	18.3	6.8	5.6	A
C13	20.1	18.6	51.4	6.5	3.4	M
C14	16.3	56.1	19.4	3.3	4.9	O
C15	19.1	54.9	13.9	6.2	5.9	O
C16	16.3	20.5	49.7	9.2	4.3	M
C17	16.8	52.6	18.4	3.7	8.5	O
C18	49.2	19.1	19.3	7.1	5.3	A

sequentially Y6, Y4, Y2, Y3. Based on the results of the above analysis, the optimization design method for Intelligent pharmacy was subsequently implemented.

Product structure determination based on FBS modelling

The functional elements of the user requirements are derived from the analysis: straightforward medication storage, medication reminders, straightforward maintenance, an intuitive interface and intelligent medication management. Subsequently, the expected user behaviors are converted into structure types. The precise process of mapping is illustrated in Figure 3.

Intelligent Pharmacy Design Practice

Practice of Intelligent Pharmacy Design

The design elements of Intelligent pharmacy products are converted into design elements by the functional structure mapping, user requirement analysis and design element transformation, by the use requirements and scenarios of Intelligent pharmacy. Additionally, the design elements selectively fulfil the functional design of the product according to the weight division. To begin with, when designing an Intelligent pharmacy, it is crucial to prioritize factors such as human-machine compatibility, effortless drug storage and retrieval and convenient maintenance. The diagram representing the specific design effect is illustrated in Figure 4. As per the man-machine's optimal operating dimensions for the placement of the pill port and monitor, the pill port is positioned at a height of 95 cm, which corresponds to the suitable height for standing while lifting up the item. In a standing position, the monitor is designed to be positioned on the upper portion of the pill port, taking into consideration the per capita height and field of vision. This arrangement enables the pharmacist to review the medication information while retrieving the medication. Additionally, because storage space for medications is limited, the interior of the pharmacy must be as efficient as feasible. Additionally, intelligent robotic hands recognize and grasp the medications for more rapid and precise dispensing. A unique maintenance door is located in the rear of the pharmacy so that in the event of a machine malfunction, the underlying cause can be diagnosed and remedied within the establishment.

Design for Intelligent Pharmacy Interactions

Concerning interaction design, the interface has been created utilizing adult-appropriate interaction methods. The information is readily comprehensible for pharmacists due to the screen's substantial dimensions. Real-time screening and auditory feedback are implemented throughout the operation process to bolster the pharmacist's trust in the pharmacy. Subsequently, the interface design strives for maximum simplicity to facilitate information clarity and highlight critical details. In order to optimise the pharmacist's information retention, sound and illumination effects are employed to prompt the pharmacist to retrieve the medication subsequent to dispensing.

Intelligent appearance design for pharmacies

It is evident from the analysis that the user's primary aesthetic requirements are cleanliness and tranquilly in colour. Intelligent pharmacy subsequently implements a rounded cube as the primary outline shape in order to minimize the hygienic cleansing of empty space. Dark blue and white constitute the primary colour scheme. Offer pharmacists a tranquil ambience with regard to color scheme.

Results of enhanced product validation

In the design testing session, a seven-point Likert scale was utilized to gather responses from participants regarding eighteen distinct user requirements. The respondents were selected to be hospital-based pharmacists and each individual was asked to complete the questionnaire on two occasions: once to evaluate the existing dispensing system and again to assess the design practice work conducted in this research endeavor. The survey was conducted between January and February of the current year.

A total of 160 questionnaires were distributed in this study due to the effect of the small number of pharmacist practitioners. After screening out incomplete questionnaires, questionnaires that took too little time to fill out and questionnaires that were answered incorrectly in reverse questions, there were 151 valid questionnaires with a validity rate of 94% and the demographic information is shown in Appendix 5. Meanwhile, the valid questionnaires were analyzed for reliability by using SPSS and the value of Cronbach's Alpha was 0.81, which indicated that the questionnaire's reliability is acceptable for the purpose of analysis. Out of the total, males constituted 29.1% while females constituted 70.9%. The largest demographic group consisted of individuals over 35, comprising 62.2% of the total population. The second largest group was individuals aged 26 to 35, accounting for 23.2% of the population. Lastly, individuals under 25 years old made up 14.6% of the population. 71.5% of the individuals possessed a bachelor's degree or below, while 28.5% held a master's degree or higher.

The results of the questionnaire analysis can be found in Appendix 6. Based on the findings, it is evident that the enhanced Intelligent pharmacy has the potential to substantially enhance the dispensing experience of the pharmacist. Among them, C8, C12, C15 and C18 are more effective in improving user requirements.

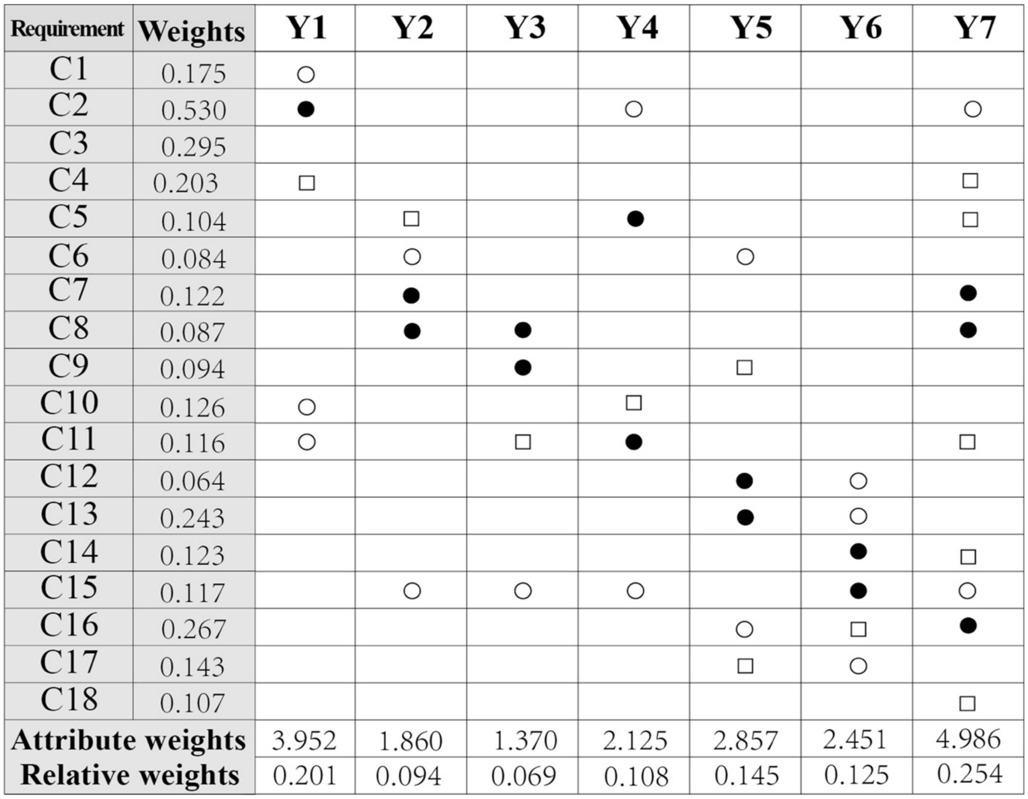
RESULTS

To address the shortcomings of the current Intelligent pharmacy system, including its cumbersome operation and limited functionality. From the perspective of the user, the KANO model is employed to conduct a comprehensive analysis and classification of the attributes associated with user requirements.

Table 3: Ranking and combined weights of demand indicators.

Demand level guidelines	Weights	Secondary guidelines for needs	Weights	Total Weight	Rankings
B1	0.184	C1	0.175	0.0322	14
		C2	0.530	0.09752	2
		C3	0.295	0.05428	9
B2	0.605	C4	0.203	0.122815	1
		C5	0.104	0.06292	6
		C6	0.084	0.05082	12
		C7	0.122	0.07381	4
		C8	0.087	0.052635	10
		C9	0.094	0.05687	7
		C10	0.126	0.07623	3
		C11	0.116	0.07018	5
		C12	0.064	0.03872	13
B3	0.211	C13	0.243	0.051273	11
		C14	0.123	0.025953	16
		C15	0.117	0.024687	17
		C16	0.267	0.056337	8
		C17	0.143	0.030173	15
		C18	0.107	0.022577	18

Table 4: QFD Quality House Construction.



Requirement	Weights	Y1	Y2	Y3	Y4	Y5	Y6	Y7
C1	0.175	○						
C2	0.530	●			○			○
C3	0.295							
C4	0.203	□						□
C5	0.104		□		●			□
C6	0.084		○			○		
C7	0.122		●					●
C8	0.087		●	●				●
C9	0.094			●		□		
C10	0.126	○			□			
C11	0.116	○		□	●			□
C12	0.064					●	○	
C13	0.243					●	○	
C14	0.123						●	□
C15	0.117		○	○	○		●	○
C16	0.267					○	□	●
C17	0.143					□	○	
C18	0.107							□
Attribute weights		3.952	1.860	1.370	2.125	2.857	2.451	4.986
Relative weights		0.201	0.094	0.069	0.108	0.145	0.125	0.254

(Note: Corresponds to the degree of relationship between user requirements and design requirements, ● which represents the strong correlation, taking the value of 5; □ represents the medium correlation, taking the value of 3; represents the weak correlation, taking the value of 1 and the two requirements have no correlation, then no marking, bringing the value of 0.)

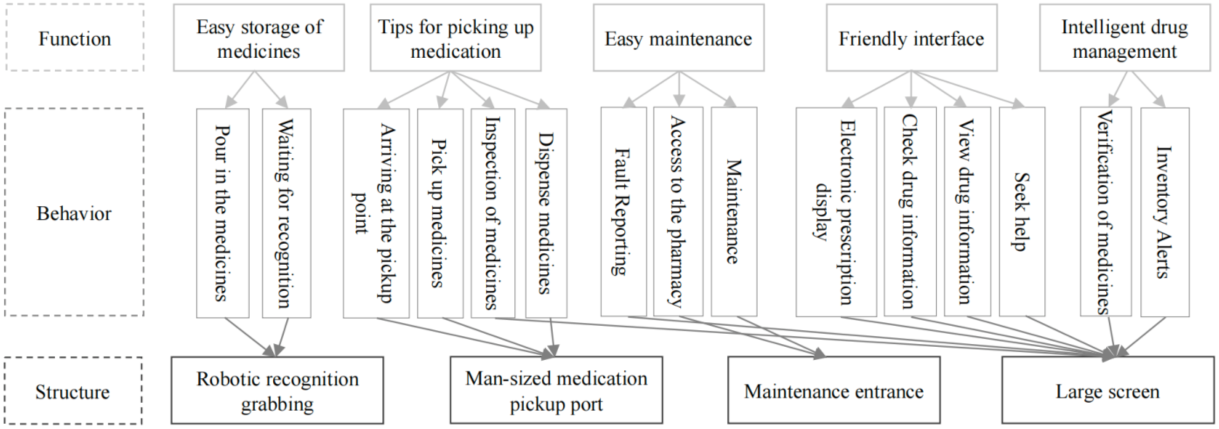


Figure 3: Functional structure mapping.

Figure 4: Product Showcase.

5/18 user requirements were classified as basic, seven as desired, five as charismatic and one as undifferentiated. Meanwhile, industry experts proceeded to assign weights to the 18 user needs by combining the AHP model. Subsequently, the QFD model was employed to transform the 18 user requirements into seven design elements and ascertain their relative importance. Subsequently, the FBS model was employed to ascertain the structure of the Intelligent pharmacy. Once the structure of the Intelligent pharmacy has been established, the next step is to implement an improved design. The efficacy of the model is gauged by a comparison of the composite scores obtained prior to and following optimization. The design process facilitated by this model has the potential to enhance user experience and satisfaction.

DISCUSSION

The results of the comprehensive ranking, which included the evaluation of the solutions, indicated that the top three user needs were: assisting pharmacists' work, an appearance applicable to hospitals and intelligent drug management. Accordingly, this section will primarily address these three areas.

The objective of the Intelligent pharmacy design should be to facilitate the work of pharmacists, with the aim of enhancing efficiency and reducing the associated workload. In the typical workday of a pharmacist, the majority of tasks are of a mechanical and repetitive nature, including the replenishment of medications, the retrieval of medications and the verification of drug-related information.[25] Concurrently, in some medical facilities, the dearth of pharmacists may precipitate an overburdened work environment for those who are available.[26] Furthermore, Intelligent pharmacy has the potential to substitute for pharmacists in the execution of repetitive and onerous tasks. Subsequently, the design process of Intelligent pharmacy must ensure that it is capable of assisting the pharmacist's work. By employing a straightforward and transparent workflow, an intuitive interaction mode and a comprehensive, step-by-step process, the Intelligent pharmacy aims to streamline the pharmacist's demanding workload. The objective is to create products that enhance the work of the pharmacist and provide services that are straightforward and highly accurate, thereby increasing the utility and ease of use of the Intelligent pharmacy.

The design should be straightforward and in accordance with human dimensions, suitable for use in a hospital setting. The hospital environment necessitates a highly functional Intelligent pharmacy design. The appearance should feature clear signage, ergonomic workstations and a reasonable motion design to ensure convenience for the pharmacist. Concurrently, hospitals have rigorous requirements for hygiene and safety,[27] necessitating that Intelligent pharmacy design be easily cleanable and sterilizable. Furthermore, the design of Intelligent pharmacy should be harmoniously integrated with the hospital's overall environment, with color matching and style that enhance the aesthetic appeal of the entire setting.

The administration of pharmaceuticals is a complex process that requires careful management. The intelligent management of drugs constitutes an essential component of the contemporary healthcare system, enhancing the efficacy, security and precision of drug administration through the integration of sophisticated technology. An automated dispensing system can effectively, rapidly and accurately dispense medications, thereby enhancing efficiency and reducing the likelihood of errors. The electronic record functions can facilitate the identification of potential drug interactions and user allergic reactions, thereby enhancing the safety of the medication regimen. The implementation of intelligent inventory management enables the provision of real-time monitoring and replenishment prompts, thereby ensuring the rationality of drug inventory.[28] The intelligent management of medicines by Intelligent pharmacy can effectively improve the efficiency, safety and accuracy of drug management through the integration of data, automation and other services. Furthermore, it enhances transparency and compliance in the management of pharmaceuticals.

CONCLUSION

The KANO-AHP integrated model partitions the user requirement attributes according to the user's perspective, while the designer assigns weights to the user requirements to conduct a more scientific and comprehensive qualitative and quantitative analysis of the user requirements. The QFD quality house model converts user requirements into design elements, thereby preventing design errors that result from designers' understanding and subjective experience biases and guiding them to prioritize among numerous user requirements. In conclusion, the FBS Functional Behavioral Structural Model is implemented to determine the essential framework of an intelligent pharmacy according to its functional components and to accurately evaluate the type of framework required to fulfill the user's functional requirements. The design process of the KANO/AHP/QFD/FBS integrated model serves as a benchmark against which the Intelligent Pharmacy design is measured. It provides a novel and inventive approach to the development of intelligent medical device designs.

However, this paper still has room for improvement in the following areas: first, questionnaire research was not conducted on a large number of users during the user research phase, which resulted in a limited amount of data due to the limited number of pharmacist workgroup personnel. In addition, the validation phase of the Intelligent Pharmacy Enhanced Design program still lacks the realism of producing a tangible Intelligent Pharmacy product for pharmacists to evaluate. Further research with a wider range of users and a more rigorous scientific validation process are needed in the future to ensure that the design solution effectively addresses the needs of pharmacists.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

KANO: The KANO model; **AHP:** Analytic Hierarchy Process; **QFD:** Quality Function Deployment; **FBS:** Functional Behavioral Structures framework.

SUMMARY

The objective of this research endeavor was to determine whether the integration of various Intelligent pharmacy models could augment the work experience of pharmacists and the overall satisfaction of patients. In addition, the objective of this research is to establish a foundation for Intelligent pharmacy system design guidelines. User satisfaction and experience can be enhanced through the implementation of the KANO/AHP/QFD/FBS integration model, according to the study. This functionality aids in the integration of medications and advances intelligent healthcare. The potential benefits of incorporating these design methodologies into Intelligent pharmacy design for patients and pharmacists are substantial.

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Appendix 1: AHP model comparison approach.

A=	T	C_1	C_2	C_3	……	C_n
	C_1	a_{11}	a_{12}	……	……	a_{1n}
	C_2	a_{21}	……	……	……	……
	C_3	……	……	……	……	……
	……	……	……	……	……	……
		a_{n1}	a_{n2}	……	……	a_{nn}

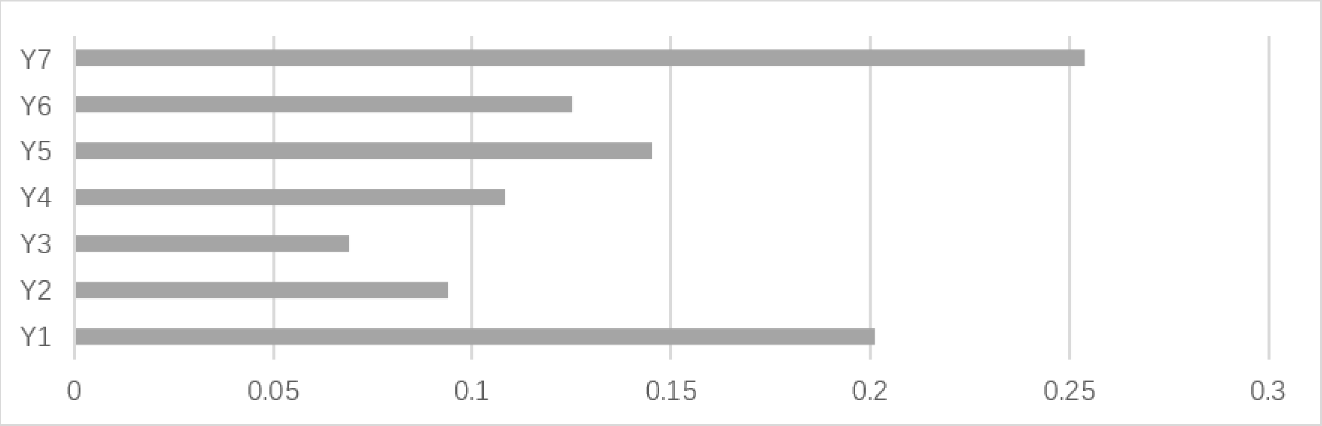
Appendix 2: The demographic information.

Variables	Options	Frequency	Percentage %
Age	18~25 years old	10	21.7
	26~35 years old	25	54.3
	Above 35 years old	11	24.0
Gender	Male	19	41.3
	Female	27	58.7
Education Level	Undergraduate	32	69.6
	Master's Degree	14	30.4
Type of hospital	Community Hospital	16	34.8
	District hospitals	14	30.4
	Municipal hospitals	16	34.8

Appendix 3: Information on invited experts.

Experts	Age	Gender	Educational level	Working Place	Occupation	Years of Expertise	Background of Expert
1	49	Male	Master	University	Professor	16	Background in Intelligent Pharmacy product development
2	44	Female	PhD	University	Professor	13	Background in smart healthcare and user experience
3	45	Male	PhD	University	Professor	17	Background in the design of medical product modifications
4	39	Male	Master	University	Professor	9	Background in Intelligent Pharmacy design
5	35	Male	Master	Industry	Technology expert	7	Working in the Intelligent Pharmacy product design industry
6	38	Female	PhD	Industry	Technology expert	9	Worked in Intelligent Pharmacy development and sales
7	44	Male	Master	Industry	Technology expert	10	Background in Intelligent Pharmacy product development

Appendix 4: Relative weight ratio of design features.



Appendix 5: The demographic information.

Variables	Options	Frequency	Percentage %
Age	18~25 years old	22	14.6
	26~35 years old	35	23.2
	Above 35 years old	93	62.2
Gender	Male	44	29.1
	Female	107	70.9
Education Level	Undergraduate	108	71.5
	Master's Degree	43	28.5
Type of hospital	Community Hospital	34	22.5
	District hospitals	84	55.6
	Municipal hospitals	33	21.9

Appendix 6: The responses to the questionnaire.