Research on Usability Evaluation of Self-Service Terminal in Chinese General Hospitals Using Grounded Theory And AHP

Xuanhui Yan[1,*]
Organization:City University of Macau，Faculty of Innovation and Design
Email: yan1110729@outlook.com

Xin Hu[2]
Organization:City University of Macau，Faculty of Innovation and Design
Email: xinhu@cityu.edu.mo

Abstract

Objective: To examine the usability of self-service terminals in Chinese hospitals, focusing on user experience issues related to human-machine interaction within the hospital information system (HIS).

Method: Utilizing grounded theory, this study generated and encoded qualitative data concerning user interaction needs with hospital self-service terminals. The Analytic Hierarchy Process (AHP) was employed to determine the importance weights of factors influencing user experience, enhancing the framework's completeness.

Results: This research identified critical usability factors such as Effectiveness, Learnability, Universality, Practicability, and Security. These factors, comprising 2-3 sub-factors each, totaling 12, significantly influence the user experience with hospital self-service terminals. An ELUPS model, a user-centered usability evaluation system, was developed to sustainably enhance HIS integration.

Conclusion: This study advances a comprehensive methodological approach for constructing usability evaluation systems through grounded theory. The findings offer theoretical guidance for the development of tangible self-service applications in hospital HIS and provide a theoretical framework for ensuring sustainable user access to self-service terminals.

Keywords: hospital information system; Human-computer interaction; usability evaluation; user experience; grounded theory; AHP (The Analytic Hierarchy Process)

1 Preface

As an integral part of the public service system, hospitals have developed enterprise-level computer network systems, namely the Hospital Information System (HIS), through the continuous maturation of information technology and the establishment of personal information network systems (Reichertz, P. L. 2006). The application of these systems and the digitization of scenarios signify a future development trend. Hospital self-service terminals, which have been implemented to reduce the workload of staff in traditional manual registration services, optimize human resource allocation, and shorten patient queuing times, enhance the efficiency of registration and payment processes.

Current research on the registration process primarily addresses the duration of registration and the complexity of the triage process. Extensive waiting times in public hospitals are a prevalent issue for individuals seeking medical care in China (Cao, W. J. et al. 2011). Despite the longstanding availability and numerous benefits of online registration platforms, many still opt for on-site registration via traditional queuing methods. The presence of these issues in self-service registration terminals and the unique interaction problems of the system warrant further investigation. A critical research question is how to reduce queuing times and assist registrants in selecting the appropriate department. Optimizing self-service terminals to offer more user-friendly services rather than manual processes is a key goal.

2 Research Background and Current Status

In the context of hospital registration services, information technology supports hospital medical record services (Wang, Y. F. 2024). A review of the literature on hospital registration systems reveals that most current research is focused on the integration of online registration systems and information technology. This focus is primarily due to differences in international healthcare processes; for example, the "diagnosis and registration" stage may not exist in certain countries, resulting in a scarcity of related research. Moreover, the inherent advantages of information technology in developing network environments shift the focus from online appointment platforms to offline self-service devices. By considering the universality of research objectives and the common challenges of triage, and synthesizing information from studies on hospital registration services and online registration platforms, common characteristics are identified.

The Hospital Information System (HIS) is a comprehensive integrated system designed to manage the administrative, financial, and clinical aspects of a hospital. Developed as an extension of the HIS, hospital self-service terminals form the core of digitalized hospital information management, extensively covering countries with IT application capabilities worldwide.

The hospital self-service terminal is a component of the HIS system that specializes in on-site outpatient registration, introduced as physical machinery and equipment for patients. Currently, most countries are focused on on-site registration services, and the equipment remains in the exploratory phase, with significant research gaps internationally.

Self-service terminals are increasingly common in various hospital settings in China, merging traditional and digital registration approaches. The physical device interacts with the user and processes services through a conventional manual registration method. Since their development and introduction to the market, research on their user-centered availability and user experience has been inadequate, with urgent problems still to be identified and a lack of availability evaluation standards.

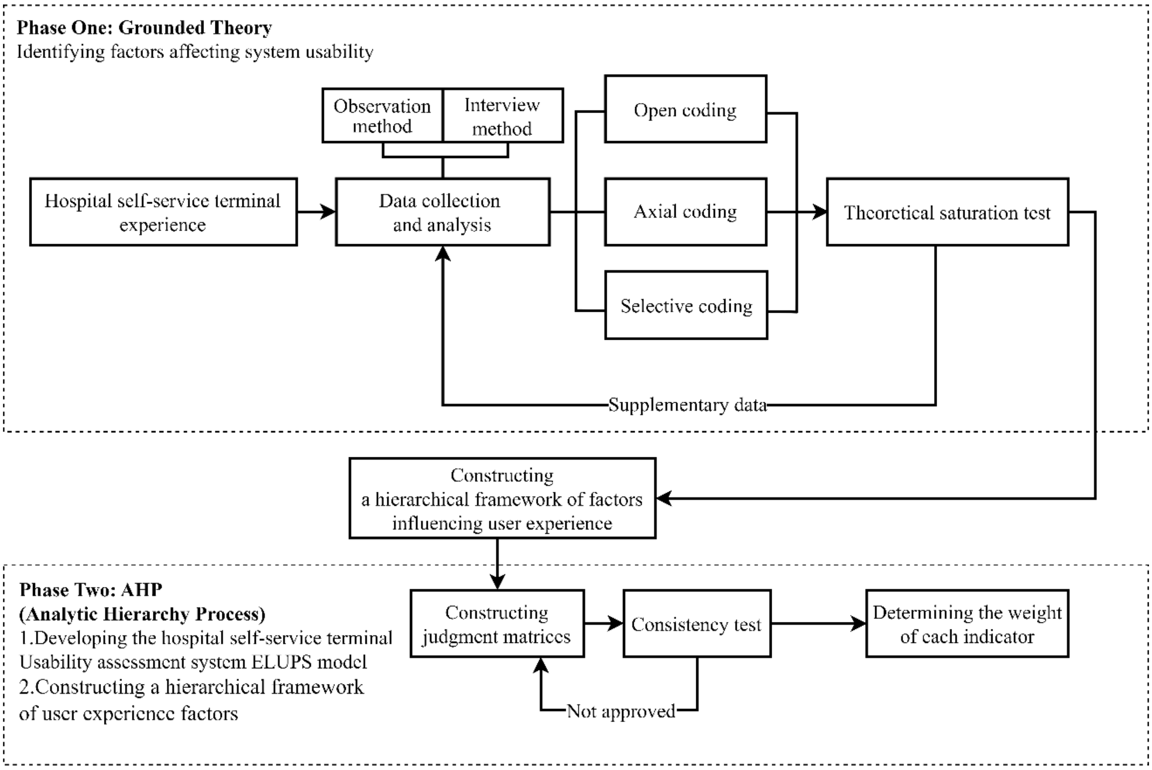
3 Research and analysis

3.1 Research methods

Outpatient registration, as the initial stage of medical treatment, consumes a significant portion of patient time, making the user registration experience crucial in the overall medical process. Moreover, it is essential to understand the patient’s interaction with the hospital, their experience using the services, and their willingness to continue using the self-service registration terminals to enhance both the design and management of these systems. The research adopts a user-centered approach, utilizing both qualitative and quantitative methods to develop an evaluation framework for the availability of hospital self-service terminals. The details are as follows.

Addressing theoretical gaps, the research was conducted from scratch, based on rooted theory (GT). It aimed to uncover the current usage of self-service terminals and develop a model for assessing their availability. The study examined the operational challenges and needs encountered by users, coding and refining the data, and summarizing availability requirements after saturation testing. The qualitative data were analyzed using the Analytic Hierarchy Process (AHP), whereby users rated the significance of each factor, calculated weights, and ranked the indicators by importance. The results culminated in a comprehensive evaluation framework. The research framework is illustrated in Figure 1.

Figure 1 Research Framework



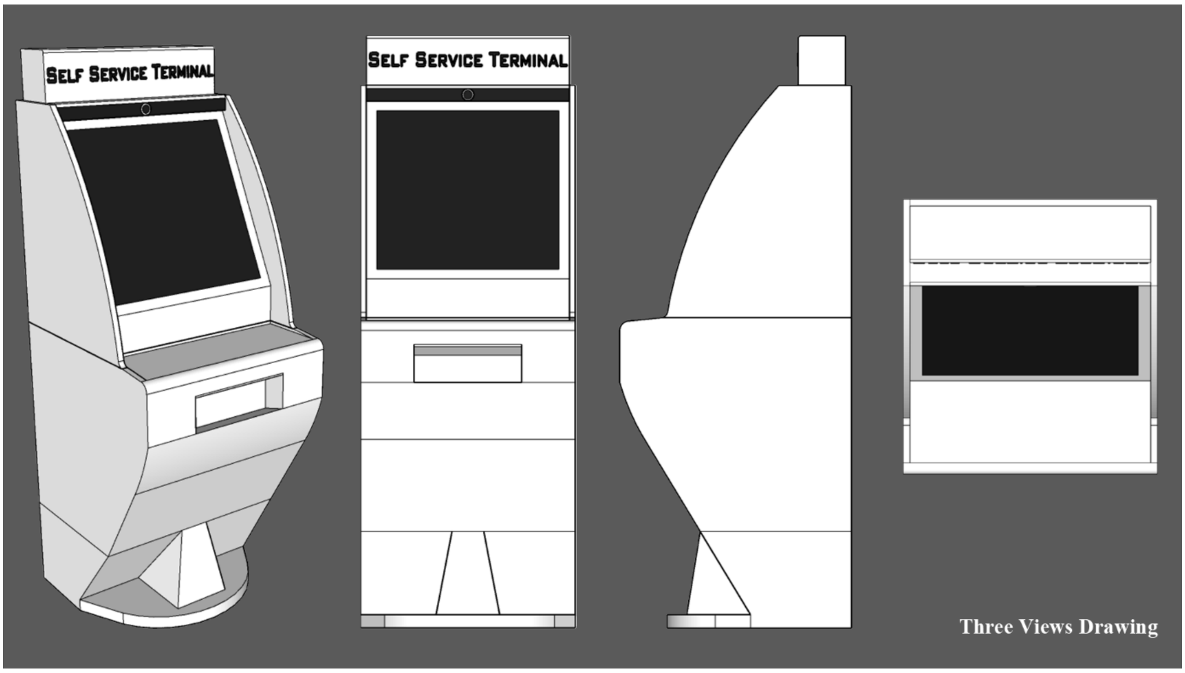
3.2 Material collection

3.2.1 On-site observation

The research initiates by examining the hospital environment, focusing on the appearance and interaction methods of self-service terminals. Hospitals customize these systems with equipment manufacturers before deployment, resulting in visual differences in appearance shapes, interface colors, and icon styles. However, despite these differences, the core functionalities of the terminals remain consistent due to the clear and fixed content of hospital self-service and user objectives.

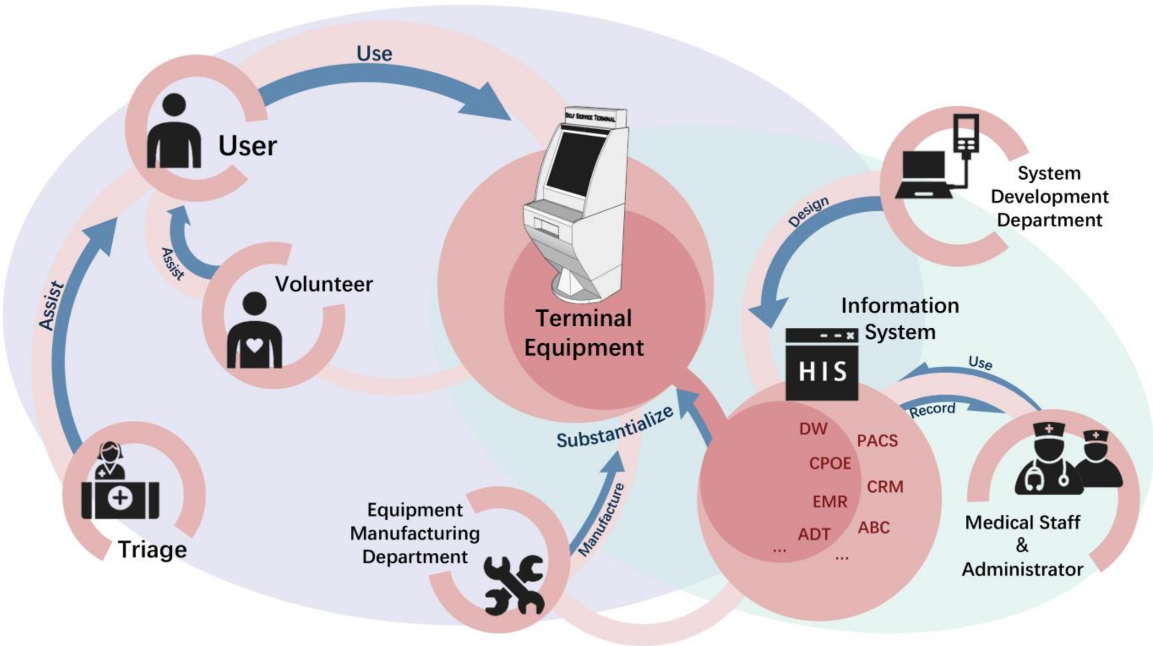
Based on the data collected, illustrations of the appearance is shown in Figures 2. Since hospitals vary in style, these figures merely summarize the basic functions for presentation purposes. Additionally, to prevent copyright disputes, the self-service terminal shown in Figure 2 features a redesigned appearance while retaining the essential functional areas.

Figure 2 External view of hospital self-service terminal



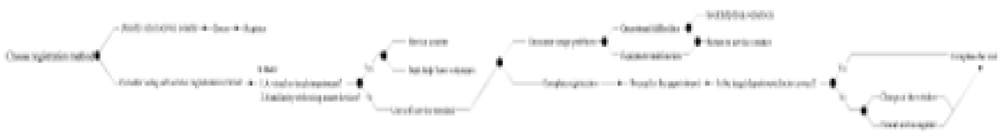
Based on the initial background investigation and on-site hospital research, a stakeholder map has been created reflecting the interactions among key departments and various personnel from the perspective of the hospital's self-service terminal, as depicted in Figure 3.

Figure 3 Map of the status quo of stakeholders in the hospital self-service terminal



Further research involves observing the complete process from patient entry to treatment completion and organizing and visualizing the user journey at each stage. This helps to better understand the user's emotions and feelings, thus identifying needs and discovering system optimization opportunities. The user journey map is segmented into three phases related to the self-service registration terminal: before, during, and after usage. It is notable that tension is observed in users even before interacting with the terminal, including the researcher, who felt nervous entering the hospital environment, thus heightening vigilance. This reaction, common due to the hospital's unique environment and various uncertainties, increases individual alertness, influencing their interactions. Although emotions are influenced by personal circumstances, they are also shaped by the environmental atmosphere (Hasse, J. 2019). Therefore, nervousness and vigilance are recognized as baseline emotions within the hospital setting, and their impact on interactions with the self-service terminal is noted. The effects of these emotions on subsequent consultations due to interaction issues with the terminal are documented in the visual user journey depicted in Figure and detailed in Table 1.

Table 1 User Journey Map

Stages	Before Use	During Use	After Use
Behavior			
Thoughts	1.Which queue has fewer people? 2.Which method has shorter registration time?	1.Inputting information incorrectly requires deleting everything and starting over; the machine is also sluggish, needing a moment to respond after each touch, which is too slow. 2.With so many departments, which one should I register with? Why isn't the department I registered with at another hospital listed here? 3.Why isn't the machine responding? Is it my mistake or is there a malfunction? 4.Maybe ask a volunteer, but they are all busy helping others right now, I'm stuck here, and the people behind me are already urging me. 5.If I go back to the counter and requeue now, it really wastes time, but staying here is pointless. 8、 Next time, I'll just go directly to the counter to register; this machine is too unstable and complicated.	1.The doctor said I registered at the wrong department, need to change and re-register. 2.Might as well go directly to the counter; repeating registration takes longer than queuing directly,
Emotional Keywords	Tense (a fundamental emotion in a hospital setting) Cautious (a fundamental emotion in a hospital setting) Indecisive	Tense ➜ Panicked Cautious ➜ Anxious Indecisive ➜ Helpless Irritable	Tense Cautious Frustrated Annoyed
Pain Points	1.Indecision about choosing the registration method (wastes more time) 2.Fear of technology associated with self-service registration terminals 3.Concerns about hardware issues with self-service terminals necessitating restarts	1.Overly specialized and inconsistent department names 2.Equipment fails to provide effective operational feedback 3.Limited number of volunteers 4.Re-selecting registration method severely delays time and affects mood 5.Frustration during interaction 6.Concerns about hardware malfunctions of the device	Incorrect department registration requires starting over
Opportunities	1.Enhance public trust in technology 2.Improve the hardware quality of self-service registration terminals	1.Ensure operation response meets the Doherty threshold 2.Increase the general understanding of department names 3.Enhance system interaction feedback 4.System automatically recognizes and notifies users of operation delays 5.Simplify repetitive step operations 6.Provide immediate alternatives for equipment malfunctions	Set up an error correction step to reduce operation repetition

3.2.2 Interview research

Interviews consist of semi-structured sessions based around 12 questions drawn from four dimensions: user willingness to use, perceived usefulness, perceived ease of use, and attitude. These questions serve to gather multidimensional information, with respondents encouraged to expand on their answers diversely.

Respondents are randomly selected from those queueing at the hospital and invited to use the self-service terminal, with interviews conducted post-treatment. The total of 60 interviewees ensures more than the required 25 for theoretical saturation. As all respondents had interacted with the terminal and completed their medical visits, they provide a representative sample for evaluating user experience.

According to the qualitative data collected in the final interview, open coding, axial coding, and selective coding were applied sequentially. Open coding identified and labeled nodes related to user experience, filtering and synthesizing key concepts. The initial scope was to refine and reorganize elements of similar nature and content. During axial coding, items with a repetition frequency of $\leqslant 3$ and inconsistent content were discarded. Ultimately, 12 initial category concepts were derived from this process.

Axial coding was conducted following open coding, where the 12 initial categories were further synthesized and organized to establish five primary categories that exhibit a logical relationship and encompass a broader conceptual level: "Effectiveness, Practicability, Learnability, Universality, Security".

After this initial coding phase, 10 additional interviews were analyzed using the same steps. No new concepts or categories emerged, confirming that theoretical saturation had been achieved. Data visualization in Nvivo15 illustrated the coded data, producing a theoretical coded view that highlights the five key influencing factors, their word frequencies, and categories. This visualization delineates three levels: keywords in the main category, sub-category, and initial category, as shown in Figure 4. The diagram's color blocks visually represent the frequency of mentions for each category's content during the interviews. Based on the initial number of concepts, the frequency of mentions for different category factors in the user interviews was also determined. The final coding results for the initial category, sub-category, and main category are displayed in Table 2.

Figure 4 Category Level Visualization Chart

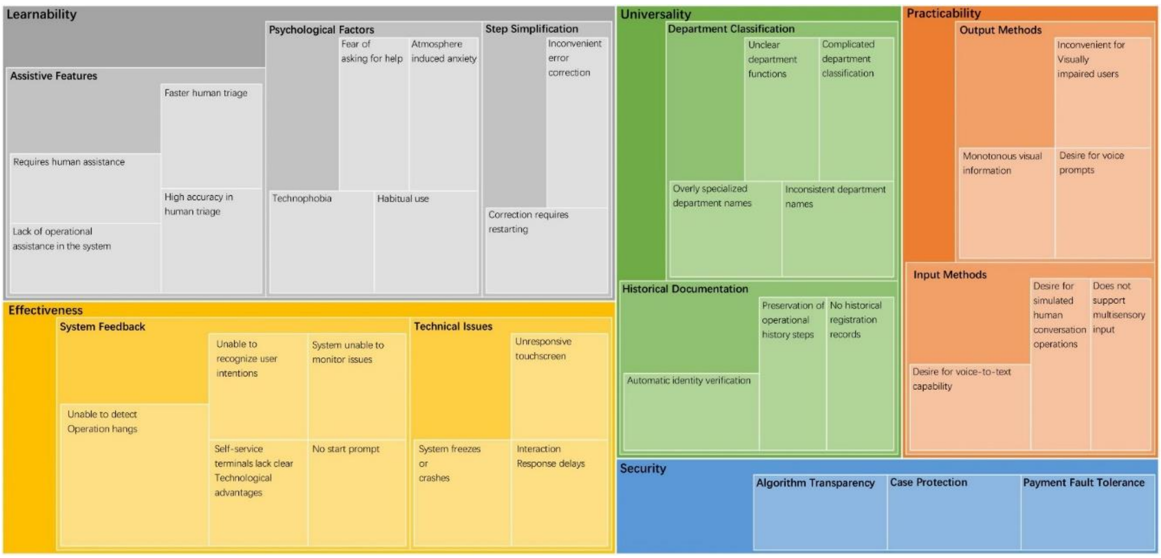
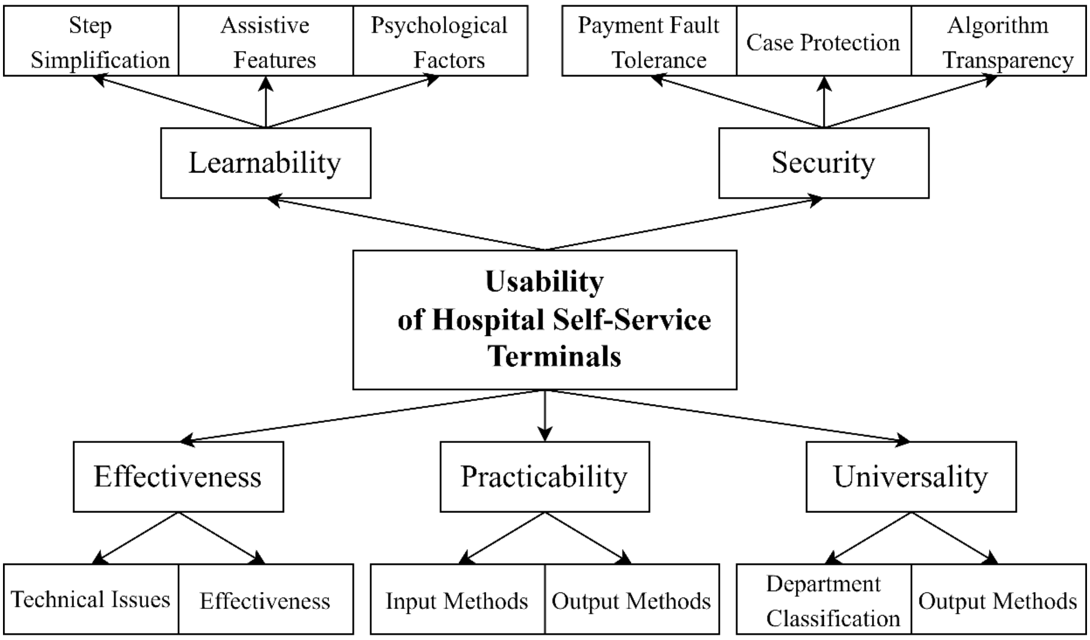


Table 2 Hierarchical Framework Diagram

Initial Concepts	Subcategories	Main Categories
c01 Unresponsive touchscreen	b01 Technical Issues	B01 Effectiveness
c14 System freezes or crashes		
c05 Interaction response delays		
c33 Unable to detect operation hangs	b02 System Feedback	
c20 System unable to monitor issues		
c18 Unable to recognize user intentions		
c08 Self-service terminals lack clear technological advantages		
c12 No start prompt		
c28 Does not support multi-sensory input	b03 Input Methods	B02 Practicability
c35 Desire for simulated human conversation operations		
c30 Desire for voice-to-text capability		
c23 Monotonous visual information	b04 Output Methods	
c34 Inconvenient for visually impaired users		
c29 Desire for voice prompts		
c02 Triage requires human assistance	b05 Assistive Features	B03 Learnability
c17 High accuracy in human triage		
c16 Faster human triage		
c21 Lack of operational assistance in the system		
c11 Atmosphere-induced anxiety	b06 Psychological Factors	
c04 Technophobia		
c03 Habitual use		
c22 Fear of asking for help		
c26 Inconvenient error correction	b07 Step Simplification	
c37 Correction requires restarting		
c19 Preservation of operational history steps	b08 Historical Documentation	B04 Universality
c27 Automatic identity verification		
c32 No historical registration records		
c09 Complicated department classification	b09 Department Classification	
c06 Inconsistent department names		
c10 Unclear department functions		
c15 Overly specialized department names		
c25 Concerns about privacy related to medical conditions	b10 Case Protection	B05 Security
c36 Concerns about information leakage		
c31 Algorithm black box	b11 Algorithm Transparency	
c24 Concerns about data collection		
c07 No confirmation prompt for payment		
c13 Irreversible payment errors		

At this point, the qualitative research method of grounded theory has been applied to identify the system availability elements of the hospital self-service terminal, comprising 5 main categories and 12 sub-categories. The qualitative results have outlined a basic framework that impacts the user experience, as illustrated in Figure 5. However, the significance of each element to the user experience cannot be solely determined by the current frequency of vocabulary mentions; this only indicates the user's clear perception of specific experiences. Consequently, it is challenging to objectively prioritize each factor's importance to the user experience based solely on user experience interviews. To develop a comprehensive availability evaluation system with significant levels and investigate the impact of different factors across various contact stages, forming a sustainable theoretical framework for the hospital self-service terminal system is essential. The research will proceed using quantitative methods to further explore the importance of these factors to the user experience and enhance the effectiveness of hospital self-service terminals, thereby improving the comprehensiveness of user experience research. Among the methods for achieving a hierarchical ranking of importance, the Analytical Hierarchy Process (AHP) is employed. AHP is a quantitative technique for addressing complex multi-objective problems that incorporates decision-makers' judgments on the relative importance of various factors. It visually presents the weight ranking through decision-makers' choices and analyzes these choices as a quantitative method for solving complex multi-objective problems. The research will continue with the AHP method, resulting in an availability evaluation model that organizes weights and a phased influencing factor framework centered on users.

Figure 5 Basic framework affecting user experience



3.3 Analytic Hierarchy Process (AHP) Weight Calculation and Ranking

This study employs the AHP to determine the weights of indicators and ascertain the importance of user experience elements. The method and specific procedural steps of the Analytic Hierarchy Process are fixed; it starts by establishing a hierarchy model specific to this experiment. It constructs a pairwise comparison matrix according to the experimental content, calculates the matrix element weight vectors using the AHP formulas, and computes the Consistency Ratio (CR) for consistency verification. Once verified, the composite weight vectors are calculated.

(1) Establishing the Hierarchical Structure Model

The model used in this paper is based on the Analytic Hierarchy Process. In this experiment, it is divided into three levels: the goal layer A, which concerns the usability of hospital self-service terminals; the primary index layer B (B01-B05), based on key factors derived from Grounded Theory; and the secondary index layer b (b01-b12), which consists of subsidiary factors related to each key factor. The hierarchical framework is shown in Table 3.

Table 3 Hierarchical Framework

Goal Level A	Primary Indices B	Secondary Indices
Usability of Hospital Self-Service Terminals	B01 Effectiveness	b01 Technical Issues
		b02 System Feedback
	B02 Practicability	b03 Input Methods
		b04 Output Methods
	B03 Learnability	b05 Assistive Features
		b06 Psychological Factors
		b07 Step Simplification
	B04 Universality	b08 Historical Documentation

		b09 Department Classification
		b10 Case Protection
	B05 Security	b11 Algorithm Transparency
		b12 Payment Fault Tolerance

(2) Establishing the Judgment Comparison Matrix

In this experiment, a comparison scale with nine ratio levels is used as the judgment scale for the elements within the judgment matrix, forming the basic component of the Analytic Hierarchy Process. The specific scale for comparing elements of the judgment matrix is shown in Table 4. Subsequently, two elements within the same level of the judgment matrix are compared pairwise according to the scale indicated in the scale table.

Table 4 Comparison Scale for Judgment Matrix Elements

Serial No.	Scale Meaning	Ratio
1	Element i is equally important as element j	aij=1
2	Element i is slightly more important than element j	aij=3
3	Element i is moderately more important than element j	aij=5
4	Element i is strongly more important than element j	aij=7
5	Element i is absolutely more important than element j	aij=9
6	Importance of element i relative to element j falls between the above judgments	aij=2,4,6,8
7	If the relative importance scale for element i compared to element j is aii, then the scale for element j compared to i is the inverse (1/aii)	Reciprocal

Analytic Hierarchy Process Weight Calculation and Ordering: By evaluating each pair of elements in the judgment matrix using the scale specified in the above table, an nth-order comparison judgment matrix A can be obtained.

$$A_{n\times n} = \begin{bmatrix} a_{11} & a_{12} & a_{1..} & a_{1n} \\ a_{21} & a_{22} & a_{2..} & a_{2n} \\ a_{..} & a_{..} & a_{..} & a_{..} \\ a_{n1} & a_{n2} & a_{n..} & a_{nn} \end{bmatrix} \quad (1)$$

(3) To obtain a unique aggregated matrix, the score matrices formed by merging the matrices of m (m=1, 2, ..., k) experts are multiplied element-wise and then the m-th root is taken. This study employs the geometric mean method, as shown in the following formula:

$$\overline{A} = (\prod_{k=1}^{m} a_{ij}^{k})^{\frac{1}{m}} \quad (2)$$

(4) The unique aggregated matrix is then further processed using the geometric mean method (root method) to calculate the relative weights of the judgment matrix, as follows:

$$W_i = \frac{(\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}}{\sum_{i=1}^{n}(\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}} \quad , \quad i = 1,2,3..,n \quad (3)$$

(5) Matrix Consistency Test the CR value is used as the basis for the consistency and reasonableness of

the judgment matrix according to academic standards. If CR < 0.1, it indicates that the matrix meets the requirements and passes the consistency test. The consistency ratio (CR) is the ratio of the Consistency Index (CI) to the Random Index (RI). If the test is not passed, experts should revise the judgment matrix until the CR is less than 0.1

Formula (4) for calculating CR.

$$CR = \frac{CI}{RI} = \frac{\lambda_{max} - n}{(n-1)RI} < 0.1 \quad (4)$$

Formula (5) for calculating CI.

λ max is the largest eigenvalue of the judgment matrix, calculated using formula (6), where $\overline{A}$ is the aggregated judgment matrix and W is the weight vector, $[\overline{A}W]i$ is the i-th component of matrix $[\overline{A}W]$

$$\lambda_{max} = \sum_{i=1}^{n} \frac{[\overline{A}W]_i}{nW_i} \quad (6)$$

The RI value depends on the order of the matrix, as shown in Table 5.

Table 5 Average Random Consistency Index (RI) Values for Judgment Matrices

Matrix Order	1	2	3	4	5	6	7	8	9	10	11	12
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52	1.54

3.4 Data Calculation

The study randomly selected 10 users who participated in interviews. They were introduced to the scoring mechanism, basic principles, and the purpose of data collection along with detailed meanings of each level of indices. This ensured that the users understood the basic experimental conditions before participating in the scoring. The calculation process and weight results after collecting the data are as follows.

3.4.1 Primary Index Weight Calculation

Weight calculations for the primary index layer (B01)-(B05) are carried out once the judgment matrices from 10 users meet the consistency requirements (CR < 0.1). The aggregated matrix according to Formula 2 after assembly is shown in Table 6.

Table 6 Integrated Judgment Matrix for BO1-BO5

	B01 Effectiveness	B02 Practicability	B03 Learnability	B04 Universality	B05 Security
B01 Effectiveness	1	4.204887	1.71177	2.992556	6.787482
B02 Practicability	0.237818	1	0.33066	0.480132	4.63092
B03 Learnability	0.584191	3.024252	1	1.04564	6.135787
B04 Universality	0.334163	2.082759	0.956353	1	4.987573
B05 Security	0.14733	0.21594	0.162978	0.200498	1

Using formulas 3, 4, 5, and 6, weights and consistency are calculated for the integrated matrix (B01) - (B05). The final CR= 0.0329 < 0.1 indicates that all weight indicators are reasonable, proving that the consistency test has been passed. Based on this, the primary index weights are determined as shown in Table 7:

Table 7 Primary Index Weights

Evaluation Indicators	Weight	Ranking
B01 Effectiveness	0.4128	1
B02 Practicability	0.1075	4
B03 Learnability	0.2475	2
B04 Universality	0.1936	3
B05 Security	0.0386	5

3.4.2 Secondary Index Weight Calculation

Following the same steps used for the primary index calculations, repeat the process for calculating the judgment integration matrix and weights for the secondary indices. The results are as follows:

(1) Index Weights After achieving consistency requirements (CR < 0.1) with the judgment matrices from 10 users, apply Formula 2 to aggregate these 10 matrices. The consolidated results produce the secondary index integration matrix as shown in Table 8:

Table 8 Secondary Index Judgment Integration Matrix

Primary Index	Secondary Index Judgment Integration Matrix			
B01 Effectiveness		b01 Technical Issues	b02 System Feedback	
	b01 Technical Issues	1	2.154031	
	b02 System Feedback	0.46246	1	
B02 Practicability		b03 Input Methods	b04 Output Methods	
	b03 Input Methods	1	1.5575	
	b04 Output Methods	0.642055	1	
B03 Learnability		b05 Assistive Features	b06 Psychological Factors	
	b05 Assistive Features	1	4.077398	b07 Step Simplification
	b06 Psychological Factors	0.245254	1	1.373497
	b07 Step Simplification	0.728069	3.250593	0.307636
B04 Universality		b08 Historical Documentation	b09 Department Classification	1
	b08 Historical Documentation	1	0.263599	
	b09 Department Classification	3.793645	1	
B05 Security		b10 Case Protection	b11 Algorithm Transparency	b12 Payment Fault Tolerance
	b10 Case Protection	1	1.592645	0.361194
	b11 Algorithm Transparency	0.627886	1	0.25416
	b12 Payment Fault Tolerance	2.768592	3.93453	1

Calculating weights and consistency for each layer of the secondary index integration matrix according to Formulas 3, 4, 5, and 6. After consolidating the results, the weights and consistency calculations for the secondary indices are as follows in Table 9:

Table 9 Secondary Index Weight Calculation Results

Evaluation Indicators	Weights	λmax	CI	CR	Consistency Verification Results
b01 Technical Issues	0.6829	2	0	0<0.1	Passed
b02 System Feedback	0.3171				
b03 Input Methods	0.609	2	0	0<0.1	Passed
b04 Output Methods	0.391				
b05 Assistive Features	0.5029	3.0009	0.000457	0.00088<0.1	Passed
b06 Psychological Factors	0.1197				
b07 Step Simplification	0.3774				
b08 Historical Documentation	0.2086	2	0	0<0.1	Passed
b09 Department Classification	0.7914				

b10 Case Protection	0.2316				
b11 Algorithm Transparency	0.1511	3.0014	0.000721	0.001387<0.1	Passed
b12 Payment Fault Tolerance	0.6173				

Based on the primary index weights and the ranking displayed in the weight summary table, the weights of each sub-category under the five main conceptual themes are shown as observed in the user's mind, similar to those in the judgment integration matrices for each level. Using the calculation results obtained above, the weights between the different levels of indices are consolidated and presented as follows in Table 10:

Table 10 Weight Summary Table

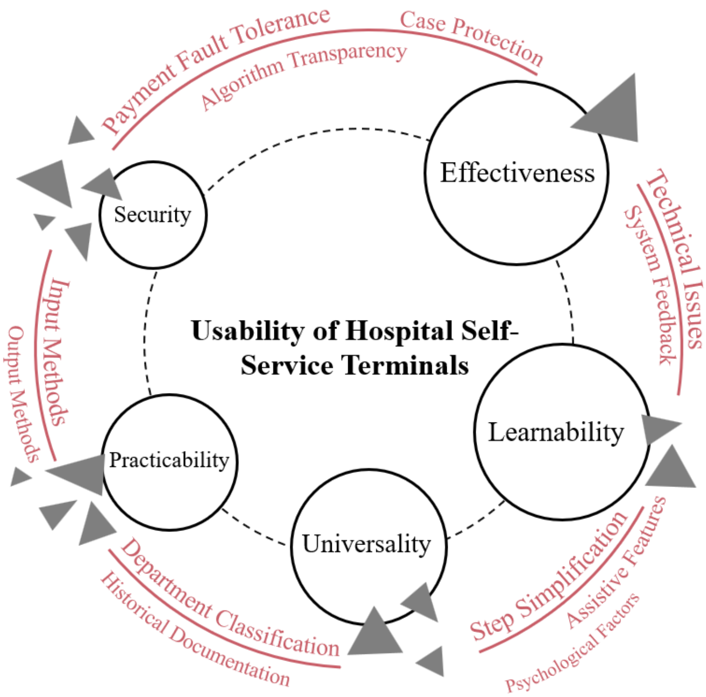
Goal Level A	Primary Indices B	Relative Weights W1	Secondary Indices b	Relative Weights W2	Composite Weights =W1*W2	Ranking
Usability of Hospital Self-Service Terminals	B01 Effectiveness	0.4128	b01 Technical Issues	0.6829	0.28190112	1
			b02 System Feedback	0.3171	0.13089888	3
	B02 Practicability	0.1075	b03 Input Methods	0.609	0.0654675	6
			b04 Output Methods	0.391	0.0420325	7
	B03 Learnability	0.2475	b05 Assistive Features	0.5029	0.12446775	4
			b06 Psychological Factors	0.1197	0.02962575	9
			b07 Step Simplification	0.3774	0.0934065	5
	B04 Universality	0.1936	b08 Historical Documentation	0.2086	0.04038496	8
			b09 Department Classification	0.7914	0.15321504	2
	B05 Security	0.0386	b10 Case Protection	0.2316	0.00893976	11
			b11 Algorithm Transparency	0.1511	0.00583246	12
			b12 Payment Fault Tolerance	0.6173	0.02382778	10

4 Data analysis

The influencing factors, ranked by weight through quantification, are: Effectiveness，Learnability，Universality，Practicability，Security. Reviewing the root theory’s word frequency ranking, the factors are: Learnability, Effectiveness, Universality, Practicability, and Security. The results of the quantitative investigation differ from those of the qualitative investigation, confirming that the hierarchical analysis method effectively improves the availability evaluation system.

To refine the framework of basic availability influencing elements, they are organized clockwise and the importance of each is indicated by the circle’s diameter—the larger the diameter, the greater the importance. The relative importance of sub-categories within each key influencing factor is denoted by font size, with larger fonts signifying higher importance. It is concluded that the hospital self-service terminal fits the ELUPS model of the usefulness evaluation system, shown in Figure 6.

Figure 6 ELUPS model of Hospital self-service terminal availability evaluation system



A sustainable system must enable user engagement, provide a positive experience during use, and encourage ongoing utilization to achieve maximum availability. This involves presenting the macro-level sustainable contact process for users of the hospital self-service terminal system. Continual engagement with users who participate in the scoring process is essential to elaborate on their criteria, explain the internal logic behind their scores, and discuss the importance of these reasons. Here, the user's willingness to use is categorized into three stages: willingness to contact, attitude during use, and willingness to continue to use. The approach combines interviews with simple tabular recordings. When a choice is selected more than five times, it is considered indicative of an impact on the level of use. The results are displayed in Table 11. The aim of this session is to identify the primary roles and reasons of different indicators at various levels, and to provide insights for the development of a sustainable theoretical framework for hospital self-service terminal systems. A summary, analysis, and description follow.

Table 11 Attitude Level selection results

	Willingness to Engage	Usage Attitude	Continued Usage Attitude
B01 Effectiveness	10 selections	10 selections	10 selections
B02 Practicability	10 selections	10 selections	10 selections
B03 Learnability		10 selections	8 selections
B04 Universality		3 selections	10 selections
B05 Security			10 selections

4.1 Effectiveness

Effectiveness impact stage: willingness to contact, attitude to use, willingness to continue to use

According to the relative weight W1 of the primary indicators of user decision-making, the validity weight value is 0.4128, ranking first among the indicators. The relative weight W2, b01 technical problem weight, is 0.6829, leading the comprehensive ranking, and the feedback weight of the b02 system is 0.3173, third in the comprehensive ranking. This suggests that equipment must be primarily effective, as all functions depend on its operational reliability. Equipment failures render assistance from staff such as volunteers ineffective, forcing users to re-queue at manual registration points, which incurs significant time costs and fosters negative emotions, thus effectiveness is deemed more critical than other indicators. In this context, 10 users identified three stages of attitudes influenced by this indicator, affecting their willingness to engage, stability during use, and decisions on future use based on current experiences.

4.2 Ease of learning

Ease of learning impact stage: willingness to contact, attitude to use, willingness to continue to use

According to the summary of weights, the relative weight W1 for ease of learning is 0.2745, with its sub-indicators ranked as follows: the auxiliary function b05 is fourth among the 12 items, the simplification step b07 is fifth, and the psychological factors b06 are ninth.

Ease of learning predominantly influences thoughts during usage, particularly noticeable during initial use. If a registration system's operations are overly complex without adequate guidance or prompts, registration efficiency is greatly reduced due to extended self-navigation times. Additionally, if queues form and volunteer assistance is lacking, this can generate considerable negative emotions, adversely affecting attitudes towards current use and influencing decisions about future use.

4.3 Versatility

The universal impact stage: user attitudes and continued willingness to use

The primary versatility index, W1, has a relative weight of 0.1936. The subsidiary index b08 is ranked eighth in the comprehensive weight ranking for historical documentation, placing it mid-tier, and second in the classification weight ranking of b09 departments. Beyond technical issues, it significantly influences the user experience through its soft impact.

Excessive specialization of department names complicates locating the appropriate consultation department, extending the process. Variations in department names across hospital systems may necessitate repetition of this step. Inconsistencies in the names of departments for the same condition across different hospitals can lead to confusion and registration errors, complicating follow-up consultations. After encountering this issue in various hospitals, users may opt for manual registration based on the urgency or discontinue use to avoid further complications.

4.4 Practicality

Practical impact stage: continued willingness to use

The primary practicality index, W1, holds a relative weight of 0.1075. Within it, the secondary indices b03 and b04 pertain to the system's input and output methods, ranking sixth and seventh respectively in overall weight. These rankings reflect the median level of user needs for system practicality.

Currently, most self-service registration terminals users encounter display information on screens and operate via touch interfaces. This setup poses challenges for those with hand or vision impairments, especially if unassisted, reducing their ability to use these terminals independently. It suggests that the interaction design of current hospital self-service terminals hinders independent usage by patients with physical or visual impairments, impacting their willingness to engage.

4.5 Security

Safety impact stage: continued willingness to use

The primary security index, W1, has a relative weight of 0.0386, ranking it lowest among the five key factors and marking a significant deviation from the others. It is the least concerning to users and hardest to detect during use. The three subsidiary indicators—b12 payment fault tolerance, b10 case protection, and b11 algorithm transparency—are the lowest ranked, positioned tenth, eleventh, and twelfth respectively.

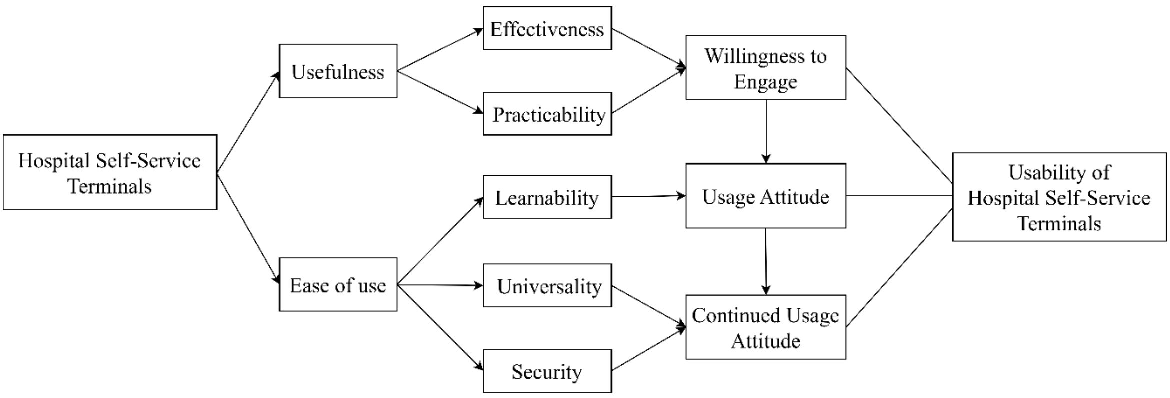
The low importance of security primarily stems from the indirect user interaction with these aspects at hospital self-service terminals. Although users express greater concern for payment-related issues, the potential for data storage within the hospital system calls for increased vigilance by the information management department. Despite minimal concerns about the self-service terminals, the ubiquitous risks in the big data era persist. The terminals serve straightforward functions, such as registration and payment, and security concerns are unlikely to alter user behavior or attitudes unless a significant data breach occurs.

5 Conclusion

The experimental results from both stages were observed, revealing that the number of user mentions in the theoretical analysis correlates positively with the level of attention. However, in assessing system usability, the importance assigned by users does not always align with the frequency of word mentions. The primary goal of examining system usability is to develop an objective impact framework. This study has demonstrated that in digitization era user experience research, particularly in usability studies, relying solely on qualitative research to identify key factors is insufficient for building an effective evaluation system; hence, quantitative methods are essential as a supplement.

A comprehensive analysis of the experimental findings has led to the development of the ELUPS model for evaluating the usability of hospital self-service terminals, as depicted in the figures. Furthermore, a theoretical framework for the sustainability of these systems was established, illustrating the relationships among user willingness to engage, attitudes towards use, and continued willingness to use. These elements collectively represent the dynamic interaction and usability of users and hospital self-service terminals, as depicted in Figure 7.

Figure 7 Theoretical framework for sustainable hospital self-service terminal system



6 Discussions and suggestions

In the future, as technology research and development progresses, digital technology should broaden its applications across various fields and scenarios. Research should focus more on user experience and the widespread adoption of technology, ensuring systems are adapted to different contexts to enhance service quality and fulfill the aims of digital equipment deployment. Targeted solutions must be developed for various scenarios and user group needs. The expansion of hospital information systems and the digitization of medical scenarios represent a general trend and inevitable direction.

This study centers on the offline self-service application model of the HIS system and provides ideas for extending the HIS system to hospital units without such applications. The research found discrepancies between the importance of influencing factors as perceived through qualitative data analysis and their actual significance. It is necessary to conduct further quantitative experiments to verify these findings, offering new insights into combining and innovating research methodologies.

At the conclusion of this study, five key factors impacting the self-service experience in hospitals were identified. The ELUPS model for evaluating system usability and a sustainable theoretical framework for hospital self-service systems were developed. These contributions offer a theoretical basis for hospital units yet to deploy related technology, addressing gaps in theoretical research. Further research is encouraged to explore and extend usage across different regions and populations, fostering the continuous development and enhancement of related studies.

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