Barriers and Enablers to the Implementation of Intelligent Guidance Systems for Patients in Chinese Tertiary Transfer Hospitals: Usability Evaluation

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Abstract – Since the early 2000s, information systems have been widely employed across hospitals in China, changing the way in which processes are managed, improving customer satisfaction and strengthening business competence. Intelligent Guidance Systems for Patients (IGSP), which resemble humanoid characteristics using Artificial Intelligence (AI), assist patients in wayfinding, obtaining medical guidance, consultations, and other medical services, and can improve user experiences before, during and after hospital visits. However, despite their widespread adoption, usability studies on such systems are scarce. To date, there is no practical or standardized measurement for system usability, leading to difficult inspection, maintenance and servicing processes. This study aims to determine the usability deficiency of IGSP and understand how various factors influence user satisfaction during their use. We employ the requirements set out in the ISO9241-11:2018 standard, using two inspection methods with 3 experts and 346 valid end-users. First, a Heuristic evaluation method was employed to detect usability problems and to demonstrate violations of Nielsen's 10 heuristic principles. Second, a System Usability Scale (SUS) was applied to evaluate participants' satisfaction towards IGSP. Finally, analysis of variance tests and a multiple linear regression analysis was performed to establish correlations between user satisfaction and characteristics.

Results show that a total of 78 problems violated the heuristic principles 169 times. These were divided into five categories: voice interaction, in-hospital navigation, medical consultation, interactive interface design, and miscellaneous. This study contributes to the existing literature on new technologies in healthcare organizations, demonstrating that IGSP can improve customer satisfaction during hospital visits.

Index Terms – Intelligent Guidance Systems; Tertiary Transfer Hospitals; Usability Evaluation; Heuristic Evaluation; System Usability Scale; Customer Satisfaction.

Managerial Relevance

This research offers important practical insights and implications for integrating IGSP into healthcare organizations to improve customer satisfaction and medical treatment standards during hospital visits. The adoption of hospital information systems brings radical changes to management processes. Strategic decision makers, however, often neglect the demands of end-users, with deficiencies resulting in reduced satisfaction, integration, and business competence. The results of this research help healthcare managers to assess the acceptance level of IGSP in hospital environments and provide recommendations for system design and modification to enhance users' technology acceptance and satisfaction. In future, usability inspection can penetrate through the management of tertiary transfer hospitals to help identify deficiencies in IGSP and to examine the issues that affect their large-scale adoption, strengthen hospital operation efficiency, and improve patient experiences.

I. INTRODUCTION

A. Background

Hospitals are notoriously difficult to navigate due to their size, complexity, and indistinguishable design. Patient and visitor experiences are often stressful and time consuming due to the labyrinth of corridors and wards that must be navigated before reaching medical treatment. Similarly, staff members face difficulties in wayfinding, especially in large hospitals, causing concern for staff well-being. In turn, this has led hospital facility designers to concentrate efforts on creating easy to use wayfinding options. For those who visit hospitals for medical treatment, they must complete numerous tasks, such as scheduling an appointment, receiving treatment, undergoing tests, and making payments. However, many patients experience difficulties, not only because these steps are complex, but also because hospitals often manage their operations differently. Due to these issues and to ensure patient, visitor and staff satisfaction, advancements in Information and Communication Technologies (ICT) have led to highly intelligent applications being introduced to hospital operations and facilities management to relieve the pressures experienced by patients [1-3]. In recent years, technologies such as Artificial Intelligence (AI), machine learning, robotics, and cloud computing, have greatly improved the delivery of medical services worldwide [4-7]. There have been increased developments in intelligent mobile health systems, such as outpatient appointment booking systems, feedback systems, and treatment tracking systems, which have been applied ubiquitously within the healthcare industry [8-10].

Among these technologies, Intelligent Guidance Systems for Patients (IGSP) have emerged and gained traction, aimed at simulating humanoid characteristics and features, such as sound and image, as shown in Fig. 1. Through the deployment of IGSP system, users can directly express their thoughts through voice communication; the system would then direct the user to target destinations based on the analysis of their voice. Further, users can operate such systems through the operational interface. The process is similar to that of smart phone applications where users swipe left or right to select their desired outcome. In addition, they can manage the process according to voice prompts on the IGSP. These systems are designed to help patients accomplish tasks during hospital visits, including navigating hospital environments, obtaining medical guidance from physicians, consultations etc. Employing advanced technologies, such as automatic speech recognition and synthesis, natural language processing, and face tracking, IGSP deliver automated medical services, improving the healthcare experience for patients before, during and after hospital visits [11].

Fig. 1. Intelligent guidance system for patients in a Chinese hospital

A. Related Work

1) Usability

The construct of usability has been widely studied in information systems and human-computer interaction literature, with significant research being completed into categorizing usability attributes to produce a systematic and standardized method of evaluation [12,13]. Yen and Bakken [14] analyzed 629 usability studies to produce a 5-stage evaluation framework from user-task interaction to user-task-system-environment interaction.

The International Organization for Standardization (ISO) initially defined usability in

ISO 9126 as “the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions”. Later, six quality categories were defined, namely: functionality, usability, reliability, maintainability, efficiency, and portability. Subsequently, usability was defined in ISO 9241-11 as the “extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” [15]. The scope of this standard has been extended to products, systems, and services to maintain consistency with other ISO standards, including ISO9241-210:2010 [16] and ISO 26800 [17] being created. In the latest standard, a wider range of goals were established, including both personal and organizational outcomes. Definitions for efficiency and satisfaction have also been issued, providing added guidance for overall inspection of system usability. Usability is composed of two parts: (1) performance, including the effectiveness and efficiency in interaction between the human and computer; and (2) satisfaction of the end user when interacting with the system, as shown in Table I.

Table I: Usability Measurement of ISO 9241-11:2018

Dimension	Description
Effectiveness	Accuracy and completeness with which users achieve specified goals.
Efficiency	Resources used in relation to the results achieved.
Satisfaction	Extent to which the user's physical, cognitive and emotional responses that result from the use of a system, product or service meet the user’s needs and expectations.

The extant literature on system usability evaluation has mainly focused on improving the effectiveness and efficiency of systems [18]. Considering the research object and application context of systems, the ISO 9241-11:2018 standard was identified as a usability evaluation framework for IGSP in our study.

2) Usability Evaluation Techniques

Usability evaluation aims to determine how well users can interact with a product to complete their goals. Evaluation techniques are commonly divided into expert-based inspection methods and end user-based empirical methods [19]. Here, inspection methods are techniques which detect problems in usability and then improve them by checking against established standards [20], including heuristic evaluation, cognitive walkthroughs, and action analysis. The empirical method, commonly employed in usability studies, refers to field observations, thinking aloud and questionnaires, which are commonly adopted when testing with end users to provide direct reflection of system use or reporting barriers in use. These two methods can, of course, complement each other [21]; the main difference between them lies in the person who performs them i.e., the inspection method is based on expert judgment, while the empirical method relies on user engagement [22, 23]. To evaluate the usability of IGSP, heuristic evaluation and the system usability scale instrument were identified as suitable methods for analysis. Heuristic evaluation is mainly used to find deficiencies in the effectiveness and efficiency of systems, while the SUS is applied to judge the degree of users' satisfaction.

Heuristic evaluation, developed by Nielsen, is the most common and practical inspection method [24] employed for usability evaluation [25]. System learnability, memorability and other components in heuristic evaluation are highly related to the effectiveness component in the ISO9241-11:2018 standard. The efficiency component also overlaps with efficiency in Nielsen's research [26]. Further, heuristic evaluation does not require user participation or special equipment, which provides multiple benefits, including low costs, high efficiency, easy to learn and use, and a high benefit–cost ratio [27-29].

The SUS, designed by John Brooke in 1996, has been widely used in research projects and industrial evaluation, proving a valuable, robust and reliable evaluation tool [30]. The SUS is based on forced-choice questioning, including 10 items with five response options, ranging from ‘Strongly Agree’ to ‘Strongly Disagree’; it further provides a stable and easy-to-understand score scale from 0 (negative) to 100 (positive) – a higher SUS score indicates a higher satisfaction towards the system. Applying this method enables evaluators to accurately measure end-user attitudes [31, 32].

The aforementioned methods are fundamental for testing system usability and have been widely applied in the evaluation of various healthcare systems. For example, 38 articles identified current best practices for evaluating healthcare applications. In addition, deficiencies in computerized provider order entry systems were rectified using the heuristic evaluation method [33, 34], with recommendations to improve usability defects being identified in 57 studies related to software engineering [35]. Moradian et al. [36] used a combination of think-aloud, semi-structured interviews, and questionnaires, to elicit patients’ views and satisfaction towards a specific self-management system. Through empirical investigation, it was found that the usability of inpatient portals impacts greatly on patients’ navigation and comprehension [37]. Meanwhile, multiple studies have proved that current systems, in line with best-practice guidelines of user-centered design, fail to verify usability during system development [2].

3) Research on Hospital Guidance Systems

Although studies focused on hospital guidance systems are common, the research objects and methods employed are often different. Kim [38] created a portable automatic guidance system using smart phones to provide patients with guidance support during hospital visits. This type of guidance system is verified by experimental evaluation and can greatly improve users' satisfaction. Wang [39] completed research into an IGSP, based on deep learning technology, and proposed that with the help of this system, patient guidance issues can be solved, providing support for improving the user experience and the efficiency of medical departments. He et al. [40] conducted research on the management of the diagnosis and treatment process of 3462 people in the outpatient department of physical examination institutions; they explored intelligent guidance, special guidance, and free inspection groups, and found that the use of IGSP can significantly reduce the amount of wasted time and repeated round-trips, compared with disordered diagnosis. Based on intelligent guidance, adding special services can significantly improve the perception physical examination and further reduce the amount of wasted time and repeated trips. Another study [41] described the system design scheme and development process of an IGSP, including functional design, robot hardware function introduction, software realization and so on. After trial, the system was observed to have a high-level of human-computer interaction, stable operation, and clear interactive interface, which effectively relieves the pressure on nurses and medical guidance, thereby greatly improving the efficiency of medical processes. Further, according to one relevant study [42], the average number of interactions between the intelligent guidance robot in the diagnostic area is about 800 times per day, which is equivalent to completing 50% of the workload of a triage nurse. The satisfaction level of patients' medical experiences has greatly improved, with the difference being statistically significant. In general, whether a hospital visitor chooses to ask someone or looks at a wall map, navigation within hospitals often calls for problem-solving skills [43], and IGSP can provide a reliable and practical way to address any shortcoming in this area.

Finally, with continued research, the degree of application of IGSP has gradually expanded and deepened. It can be concluded that, although international studies on the usability of such system have not yet been found, up to now, research in the Chinese literature on IGSP has gradually emerged, and most of these studies have focused on the introduction or applications of the system.

B. Objectives

A system which provides smooth interaction for users will be effective in promoting patient engagement, while systems with poor usability design will bring about frustration in user experiences. Despite the advantages offered by information systems in hospitals, many researchers still point out the difficulties that impede their successful implementation. There is no doubt that the roll-out of a new system, without proper usability evaluation, leads to user misunderstanding and incorrect interaction; users would also fail to achieve their tasks and ultimately become frustrated [44]. If problems in the system are identified and removed prior to roll-out, patients will ask for less support from nurses or hospital Information Technology (IT) experts. Thus, continuous evaluation is crucial for maintaining system usability [45].

The primary purpose of this study is to evaluate the usability of IGSP in hospital environments. Based on the system deficiencies identified, specific suggestions for future optimization will be provided. We aim to identify the relationships between user satisfaction scores and key influencing factors. The results of our investigation can help strengthen hospital management and provide patients with increased convenience and efficiency during hospital visits, leading to heightened satisfaction.

II. METHOD

A. Research Design

IGSP have been widely embedded into tertiary transfer hospitals in China. We investigated the active systems of three public tertiary transfer hospitals in Wuhan, a central city in Mainland China. Although the three hospitals were of different sizes, including differences in number of beds, outpatients, and emergency patients, all three hospitals were equipped with the same IGSP. Besides, to ensure the comparability and objectivity of our research results, the functions of the three IGSP performed in this research are more representative to the IGSP. The usability evaluation complied with the ISO9241-11:2018 standard. The research framework employed is shown in Fig. 2.

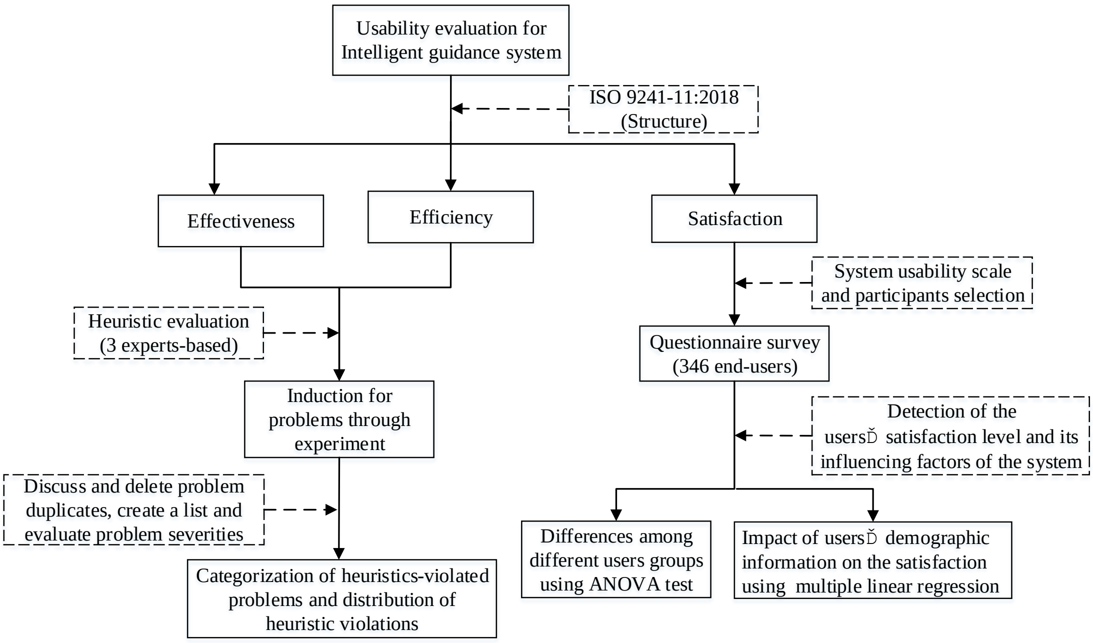

Fig. 2. Diagram of research design. ISO: International Organization for Standardization; ANOVA: Analysis of Variance.

B. Expert-based Heuristic Evaluation for Intelligent Guidance System for Patients

Nielsen [46] established that only three to five evaluators, with usability expertise, are required to sufficiently detect on average 74-87% of usability problems in a system. In this section, four main functions of the system have been selected and detected, i.e., outpatient guidance, medical triage, appointment register, complete payment. We recruited three postgraduate students with backgrounds in medical informatics as usability evaluators. Three phases of the heuristic evaluation were conducted, including prior training, evaluation, and review [47]. First, an overall inspection of the systems was conducted and then professional training on heuristic evaluation was completed [48]. Second, the 3 evaluators analyzed the system independently, three times, with no discussion. While inspecting, they were also required to take notes and provide a brief explanation of problems identified which violated 10 heuristics, i.e., visibility of system status, match between system and the real world, user control and freedom, consistency and standards, error prevention, recognition rather than recall, flexibility and efficiency of use, aesthetic and minimalist design, help users recognize, diagnose, and recover from errors, and help and documentation [49]. Then, an organizer was selected to summarize all notes taken, delete duplicates, and create a complete list of all identified problems. Third, according to the nature, impact and persistence of the problems [50, 51], the organizer structured and categorized the listed problems; a ranking of the problems was subsequently established. Thereafter, a descriptive analysis of the number of problems and violations was employed to identify the main deficiencies in the effectiveness and efficiency of the IGSP system.

C. User-based System Usability Scale Surveys for IGSP

1) Questionnaire Design

Recent research [52] shows that SUS provides a global measure of system satisfaction and sub-scales of usability and learnability. This means we can track and report on both subscales and the global SUS score [53]. This study employed the scale to measure the perceived usefulness to users, which is called satisfaction, one of the three usability indicators mentioned in the ISO9241-11:2018. Since its introduction in 1986, the 10-item SUS has been assumed to be unidimensional [54]. Because a distinction based on item tone is of little practical or theoretical interest, it is also recommended that user experience practitioners and researchers generally treat the SUS as a unidimensional measure of perceived usability [55]. Meanwhile, it must be pointed out that the SUS has 10 five-point items with alternating positive and negative tones, which can reduce to a certain extent the selection bias caused by the framing effect [56] to users. Furthermore, the standard approach to scoring the SUS is quite objective and stable to manipulate the score to range from 0 to 100 [57], Thus, compared to the other prevalent scales such as Computer System Usability Questionnaire, Questionnaire for User Interaction Satisfaction [58], SUS offers the benefit of being free and convenient, and is a relatively suitable tool for this survey to detect users' satisfaction level. Therefore, a questionnaire with 18 items was designed to quantify users' satisfaction with the IGSP. The SUS was incorporated to examine user satisfaction, as it can be administered easily and in a relatively short period of time [59]. The remaining 8 questions related to demographic characteristics, such as gender, age, education, etc. In addition, experience with smartphones and computer systems was also considered.

2) Data Collection

According to ISO 9241-11:2018, intended users are differentiated by the characteristics of the users, tasks to be completed, and the environment in which the task is taking place [15]. Therefore, before the questionnaire was administered, a pre-test questionnaire for end users' demographic information was completed. Participants were required to complete a series of questions, including 6 components: (1) age, (2) gender, (3) education, (4) residence, (5) IT experience, and (6) profession. After the pre-test experiment, we improved the post-test scale by, for instance, optimizing the division of users' age groups, the scope of users' occupations, and other important items. In this regard, we followed standard experimental procedures. As stated in the study [60], the main steps included: (1) Identification of evaluation objectives, (2) Sample selection and study design, (3) Selection of representative experimental tasks and contexts; (4) Data collection video recording and recording of thought processes; (5) Analysis of the process data; (6) Interpretation of findings. The formal survey was conducted in April 2019, with the participants recruited all having used the IGSP during their visit to one of the three tertiary transfer hospitals. All participants were required to complete the task of outpatient guidance and triage functions. In addition, to ensure the effectiveness of the research, we distributed small gifts to the participants to ensure the validity of the data.

The screening criteria were as follows: (1) participants of 14 years of age or older, (2) had prior experience with IGSP, (3) could understand the questionnaire and provide their own responses accurately and independently, (4) consented to participate in the study, and (5) able to express their opinion correctly. 120 respondents were selected from each hospital by the research assistants who had received training in the convenience sampling technique. After unqualified questionnaires were rejected, 346 valid responses were collected from all the 360 questionnaires; the response rate was 96.11%; this rigorous approach is helpful in gaining a better reflection of the degree of users' satisfaction with the IGSP.

3) Data Analysis

The adjective rating scale, developed by Aaron Bangor [61], was employed to determine the mean SUS score. Similar to the standard letter grade scale, products scoring in the 90s were exceptional; products that scored in the 80s were good; and products that scored in the 70s were acceptable. Anything below a 70 were deemed to have usability issues which were cause for concern. This rating scale can help practitioners interpret individual SUS scores and assist in the explanation of results for non-human factors. Obviously, the SUS could be further used to measure users' satisfaction [23, 62].

Furthermore, statistical analysis was conducted to detect the different significant influential factors dependent on the SUS score. An Analysis of Variance (ANOVA) test was completed to perform a comparison between users and hospital category characteristics. Multiple linear regression was also conducted to determine to what extent those associated factors could contribute to the final score of the SUS. Using the standard $\alpha = 0.05$ cutoff, the null hypothesis is rejected when $p<0.05$ and not rejected when $p>0.05$ for all analysis, which was performed using IBM SPSS Version 20.0.

II. ANALYSIS AND RESULTS

A. Categorization and Distribution of the Heuristic-violated Problems

A single usability problem identified by an evaluator could violate a set of different principles. Thus, the number of heuristic violations is typically far greater than the number of usability problems identified. After integrating the problems and removing any duplicates, 78 problems were identified which violated heuristics a total of 169 times.

All problems identified were divided into five main categories: *voice interaction,* *in-hospital navigation, medical consultation, interactive interfaces design, and miscellaneous*. The largest number of problems and the most frequent heuristic violations lie in the *medical consultation* category, with 27 problems identified. *Interactive interfaces design* included 21 individual problems. It should be noted that the problem number for *voice interaction* and *in-hospital navigation* were both relatively modest, with only 10 and 14 problems being found, respectively. The remaining 6 problems were included in *miscellaneous.*

There are different percentages of the 10 identified heuristics-violated problems. *Flexibility and efficiency of use* was the most frequently violated heuristic, with 42 (42/169, 24.85%) violations found. *Match between system and the real world* occurred 26 times (26/169, 15.38%), while *User control and freedom* had 21 violations (21/169, 12.43%). These three heuristics accounted for 68.12% of all violations. On the other hand, the fewest occurrences related to *Help and documentation* with 4 violations, accounting for 2.4% (4/169) of the total violations.

B. User Satisfaction Evaluation

As shown in Table II, the age of end users ranged from 14 to 85. The majority of users were aged between 19 to 35, accounting for 59.8% (207/346) of the total. Females comprised 60.7% (210/346) of total respondents. Most respondents (227/346, 65.6%) had received a college or higher level of education, while approximately 92.5% (320/346) lived in urban areas. With the accumulation of IT experience and daily smartphone usage, the number of respondents in the corresponding groups is continually growing. Except for Miscellaneous, participants working in the services industry accounted for 16.4% (67/346) of total responses, followed by the healthcare and education industries. It should be noted that the total percentage of those employed in the agriculture, forestry, fishery and food industry was less than 2%.

Table II: Participant characteristics (n=346). IT: information technology

Characteristics	Frequency	Percentage (%)
Gender		
Female	210	60.7
Male	136	39.3
Age (year)		
14-18	15	4.3
19-35	207	59.8
36-50	66	19.1
50-59	42	12.1
⩾60	16	4.6
Education		
Primary school or lower	47	13.6
Primary school-high school	72	20.8
Bachelors	208	60.1
Master and above	19	5.5
Residence		
Urban	320	92.5
Rural	26	7.5
No. of years using smartphones		
<1	10	2.9
1-3	26	7.5
3-5	45	13.0
5-7	73	21.1
7-9	87	25.1
>9	105	30.3
Smartphone daily usage (hour)		
<1	20	5.8
1-2	18	5.2
2-3	39	11.3
3-4	53	15.3
4-5	75	21.7
>5	141	40.8
Experience of using IT (year)		
<1	98	28.3
1-5	53	15.3

5-8	37	10.7
8-12	53	15.3
12-15	35	10.1
>15	70	20.2
Participants' profession		
Computing or Internet	23	6.6
Finance	18	5.2
Service	67	19.4
Manufacturing	30	8.7
Food	4	1.2
Education	29	8.4
Agriculture, forestry, fishery	2	0.6
Health care	66	19.1
Miscellaneous	107	30.9

The average SUS score was 72.8 (SD 14.69), which ranged from 17.5 to 100 (82.5-point variation). Such results demonstrate a good satisfaction level and that a large contrast exists in user attitudes towards the system, as shown in Fig. 3.

The lowest quarter of responses fell at 62.5 and below, while the best four response ratings ranged from 87.5 to 100.0. The individual score with above 72.5 took up 51.7% of all samples; the group of 87.5 held the highest percentage of 9.2%, followed by the group of 80 and 75.

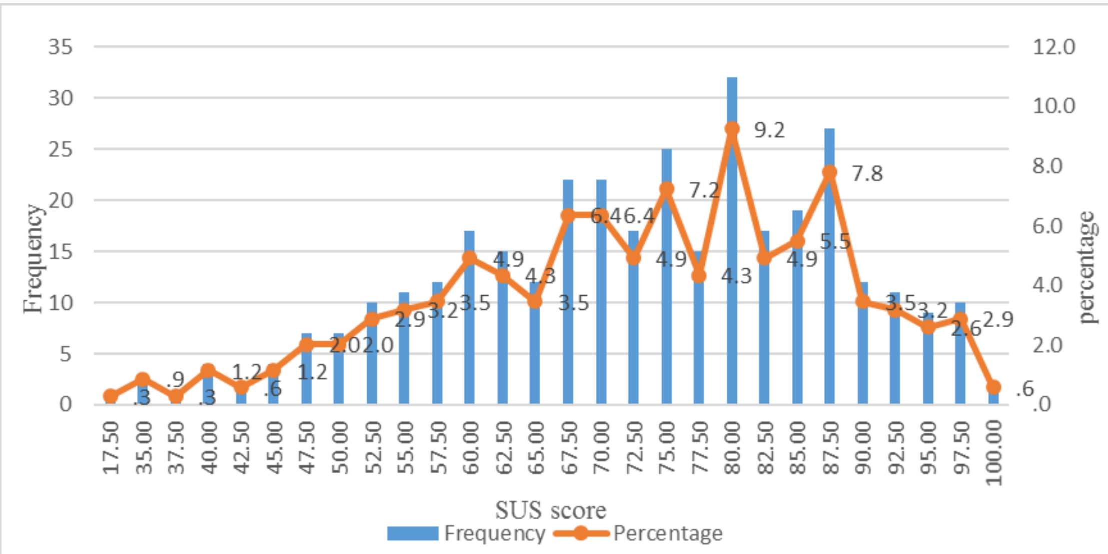

Fig. 3. A frequency and percentage histogram of system satisfaction score. SUS: system usability scale

C. Comparison between Participants' Satisfaction Scores

Table III shows the key differences among hospitals and patients' characteristics using ANOVA tests. User satisfaction scores differed among hospitals ($F=3.513$, $p=.031$), age ($F=6.010$, $P<.001$), experience of smartphone usage ($F=4.781$, $P<.001$), daily smartphone usage time ($F=2.874$, $p=.015$), and experience of IT ($F=3.846$, $p=.002$). All groups satisfied the homogeneity of variance and normality test. We found that there was no statistically significant difference between the SUS score and education, profession, and other factors, respectively. However, there did exist statistically significant differences for hospital SUS scores. Among all 5 age groups, those aged 50 or above and those below the age of 50 had a statistically significant difference. Further, with the age growing, the mean score for each group obviously decreases. In relation to the differences between smartphone usage and IT experience, users who had never used or used for less than one year had a statistically significant difference from those who had used for more than one year ($p < 0.001$). In comparison to IT experience, the group with '15 years or above' were 10.6 higher than those with '1-3 years' of experience. Further, when compared with users' daily smartphone usage, there was a positive effect on daily usage and user satisfaction with the IGSP.

Table III: Analysis of variance tests for the System Usability Scale scores of the three hospitals and participants' demographic information. IT: information technology

Measures	Sum of squares	Degrees of freedom	Mean square	F(df1, df2）	*P* value

Hospital					
Between groups	1527.219	2	763.610	3.513	.031
Within groups	95640.079	344	217.364	_a	_
Total	97167.297	346	_	_	_
Age					
Between groups	5055.576	4	1263.894	6.010	.000
Within groups	92111.721	342	210.301		
Total	97167.297	346			
Smartphone usage experience					
Between groups	4899.038	5	979.808	4.781	.000
Within groups	70094.281	341	204.954	_	_
Total	74993.319	346	_	_	_
Mean daily smartphone usage					
Between groups	3024.413	5	604.883	2.874	.015
Within groups	71968.906	341	210.435	_	_
Total	74993.319	346	_	_	_
Experience of using IT					
Between groups	3992.346	5	798.469	3.846	.002
Within groups	71000.973	341	207.605	_	_
Total	74993.319	346			

[a]N/A: not applicable.

Table IV demonstrates the relationship between the SUS score and user characteristics. In the original regression model, with all independent variables included, 4 covariates were statistically significant (F=5.642, P<.001). It was found that education, an important factor, could deliver a negative effect on user satisfaction (t=-2.41, p= .016). The standardized coefficient of education was -.142, which means that the higher a user's education, the lower satisfaction score they provide. Users' occupation was also a vital predictor that could greatly influence the degree of satisfaction, especially for those employed in the medical industry (t= -2.074, p=.039). The standardized coefficient for the medical industry was -.111; when other covariates were kept constant, the user satisfaction score would decrease by 11.1%. Additionally, as one of the variables in the regression, females (t= -2.080, p=.038) provide lower satisfaction scores than males. It should be noted that daily smartphone usage time (t= 2.470, p=.014) can greatly help to increase user satisfaction scores.

Table IV: Factors associated with patient satisfaction scores in the multiple linear regression

Variable	B	SE	T test(df)	*P* value
Education	-2.619	1.087	-2.410	.016
Daily smartphone usage	1.347	.545	2.470	.014
Medical	-4.130	1.991	-2.074	.039
Female	-3.292	1.583	-2.080	.038

III. DISCUSSION

A. Principal Findings

This study identified a range of potential usability problems and demonstrated how participant demographics can influence satisfaction when using IGSP. Several problems were identified in the area of efficiency and effectiveness through heuristic evaluation, with problems mainly relating to system flexibility and efficiency. The system usability scale was employed to conduct user satisfaction testing, with the average score being greater than 70, meaning that the system had a good ease of use. Furthermore, it was found that participant characteristics, including education, gender and occupation, exerted influence on submitted satisfaction scores when using IGSP.

1) Basic principles of system design for intelligent guidance systems for patients should be further highlighted.

During heuristic evaluation, flexibility of use, match between system and the real-world, user control and freedom, and flexibility and efficiency of use, totaled 53.37% of all violations, identifying high concern. It was found that the relatively small interface screen, simple color schemes, and obscure fonts used, made it difficult for users to perform tasks smoothly. Further, the studied IGSP lacked a reliable and effective mechanism for error correction, while customizable languages were also neglected, meaning that users whose native language was not English found it difficult to interact with the system; this is consistent with findings of other studies [63]. In addition, it is suggested that information relating to doctors' specialisms and their clinic operating hours should be updated more frequently to ensure patients are provided timely and accurate information. The system's interface must be simplified to ensure inclusion for all. Furthermore, task interruption and reduced system speeds were often caused by instabilities in hospital internet networks, which was one of the main reasons for inaccuracy in voice navigation. Most medical terms indexed in the IGSP were provided by medical professionals, but immaturity in voice interaction has become a fundamental cause for ineffectual medical consultation. Therefore, tertiary transfer hospitals should make greater efforts to develop IGSP based on basic design requirements, improving the usability of the product.

2) Demographic characteristics have different effects on the system usability scale score.

Satisfaction scores were significantly related to users' personal characteristics. It can be found that the individual differences could bring a large deviation in individual satisfaction scores, ranging from 17.5 to 100; this trend is consistent with the research of Bangor [32, 61]. Compared to younger users, older people had a relatively lower rate of satisfaction and acceptance, indicating that unfamiliarity with new technologies led to confusion and poor performance; this is in line with Zhao's finding [64]. Specifically, a young person who is experienced in the use of new technology may consider that such a system is not sufficiently challenging or user-friendly to them, and therefore records a low satisfaction level. With regard to users without a medical background or with a basic medical knowledge, it is easy for them to be misled or misinterpret information during interaction.

Users with a higher educational background (college level or above) demonstrated a negative influence on their SUS score due to their greater knowledge and ability levels. It is reasonable to state that their ability to process information and applications, together with their proficiency in the use of electronics products, would be relatively high. Thus, they would always consider IGSP to be only one of the ways to collect information and complete their identified task; they can obtain real-time support in many other ways, such as via the hospital website or tailored applications or programs provided by the hospital.

Similar to existing studies [5], misdiagnosis happened frequently, with patients choosing to withdraw or reject the technology, when this occurred. In line with previous research [65], a user interface which is 'elderly friendly' would be conducive to preventing a 'reluctance to use' by elderly users; thus, it is imperative that end-users are considered to be an indispensable part of the system, especially in the early stages of system design. Some measures have proven to be best effective practice in this regard, including providing large fonts, clear features with simple instructions, and distinguishable color schemes for system display [66].

3) User-centered design for intelligent guidance systems for patients should be strengthened.

F-tests conducted in this study demonstrated that there was a significant difference between users who are highly experienced in IT and smartphone usage and those who had limited experience. Nevertheless, we did not find significant differences among the average SUS score of other user groups. In addition, we found that different hospital sizes and administration patterns exerted impact on end-user satisfaction towards the system. As commonly understood, the numbers of patients waiting for medical treatment and the number of visiting outpatients and emergency patients is growing each year [67]. Waiting times are soaring globally, while satisfaction with hospital visits is dropping. Therefore, if patients' waiting times could be shortened, satisfaction levels with such systems (and even the overall medical experience) can be greatly improved [68].

External factors can also have an influential impact on user satisfaction. We found that the adoption of electronic equipment had a negative effect on users' acceptance of the system. Mobile healthcare applications are a valuable tool which could help solve identified problems, such as those related to medical navigation and medical consultation [69]. In addition, smartphone daily usage time is positively correlated with its SUS score; in other words, if a user's acceptance of electronic products is higher, they are likely to also give a higher rating to the system correspondingly. Consequently, as IT integrates into daily lives, users have become accustomed to utilizing specialized operating systems to resolve their problems. Compared to mature technologies, new emerging ones cannot meet the users' demands completely.

4) Settings for the adoption of intelligent guidance system for patients should be optimized to enhance user satisfaction.

Voice interaction, as one of the most important functions of IGSP, not only asks for optimization of internal structures, but also external operational environments. Therefore, hospitals, in partnership with developers of IGSP, should further investigate how to optimize internal and external settings of IGSP, to provide a convenient and rapid service to patients, which alleviates the pressure of patients queuing for medical treatment. To sum up, through the collaborative efforts of multi-parties, the adoption of IGSP will effectively enhance the operational efficiency of hospitals, improving overall user satisfaction.

In addition, patients' unfamiliarity with hospital environments leads to their ineffective movement around the hospital and limited medical treatment time. To our knowledge, services provided by specialists or nurses are relatively reliable. Timely and reliable tips or assistance from nurses will greatly improve the patient's experience during their medical treatment. Additionally, human-computer interaction could be improved to heighten user satisfaction levels. From both an internal and external perspective, user-centered design should always be put first to improve patient experiences.

B. Implications

The adoption of hospital information systems brings radical changes to hospital management processes. However, systems are frequently developed with inadequate consideration for demanding end-users. System deficiencies bring negative effects to end-users, even hampering clinical integration in practice settings [70]. Thus, based on the ISO 9241-11:2018 standard, we attempted to gain a better understanding of the usability of IGSP through a mixed approach, exploring the views of experts and end-users. As mentioned, our results help to assess the acceptance level of IGSP and to identify the influencing factors and ensure a smooth flow in hospital operations [71]. Usability evaluation is necessary to identify usability violations, and provide recommendations for system design and modification, enhancing the users' acceptance of and satisfaction with technology. Usability inspection could penetrate through the management of tertiary transfer hospitals in the future; identifying deficiencies in IGSP would be helpful in examining the issues that affect their large-scale adoption, strengthen hospital operation efficiency, and improve patients' experience in hospital. In addition, this study contributes to the research and development of better health applications.

C. Limitations

In this study, we employed a mixed method approach to investigate the usability of IGSP. Of course, there were several limitations to our study. First, participants were chosen using a convenient randomization method, which is insufficient for representing users nationwide. Nonetheless, since the sample size was relatively large and the respondents were selected conditionally, we ensured that our data was still well represented, to a certain extent. Second, although we made the greatest efforts to ensure all participants could complete the questionnaire and provide genuine responses, the SUS for the questionnaire, translated from English to Chinese, might bring about slight bias to participants [72], affecting the accurate transmission of the original meaning. Third, although the IGSP possesses many functions, as introduced, we chose two main functions for guidance and triage for user experimental tasks. As the hospitals used different scales with some discrepancy in management capabilities and technical means [73], not all functions could be implemented in the three hospitals examined in the same experiment. Therefore, to complete the comparative study and ensure that users could carry out experiments on the same task level, all participants were required to finish tasks for guidance and triage. Thus, future research could be carried out into the different types of experimental tasks, to ensure user-based research is more comprehensive and practical.

IV. CONCLUSIONS

Based on the structure of ISO 9241-11:2018, this paper explored the usability of IGSP using two evaluation methods. Through heuristic evaluation, we summarized the main problems into five areas of the system, including 78 usability problems of varying degrees, which violated the heuristics 169 times. Several deficiencies were detected in our study, including complicated operational processes and a lack of user-centered conception during system design and maintenance. These problems decrease system performance, which leads to a reduction in user satisfaction. These findings provide great help for the improvement of IGSP, in future. Additionally, we completed a user satisfaction evaluation test with the SUS. A questionnaire containing 18 questions was employed, which covered users' attitudes toward IGSP usage and users' characteristics. The degree of satisfaction with IGSP was rated good, with the average SUS score being 72.8. It was found that satisfaction scores were related to individual differences. We also found that such a system was not completely accepted by its users. The satisfaction scores ranged from 17.5 to 100, suggesting that user centered improvements are needed to make this system more acceptable. Although we have discovered some of the problems hidden in the system, it is still far from sufficient. Future research directions should focus on the exploration of other new practical methods to provide a more thorough overall inspection.

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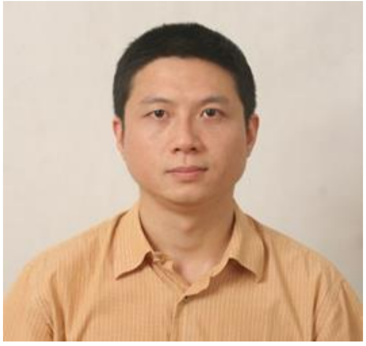 **Zhiguo Zhang** received his PhD in Social Medicine and Health Management at Huazhong University of Science and Technology, China. He is currently Associate Professor in the School of Medicine and Health Management in Tongji Medical College of Huazhong University of Science and Technology. He is also the Director of the editorial department of *Journal of Medicine and Society* as well as the Associate Director of Hubei Provincial Research Center for Health Technology Assessment affiliated with the Health Commission of Hubei Province, China. His main research interests include economic evaluation in health technology assessment, financing and payment of basic medical insurance, and health statistics.

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