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Determinants of intention with remote health management service among urban older adults: A Unified Theory of Acceptance and Use of Technology perspective

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Background: Although older adults health management systems have been shown to have a significant impact on health levels, there remains the problem of low use rate, frequency of use, and acceptance by the older adults. This study aims to explore the significant factors which serve as determinants of behavioral intention to use the technology, which in turn promotes actual use.

Methods: This study took a total of 402 urban older adults over 60 years to explore the impact of the use behavior toward remote health management (RHM) through an online questionnaire. Based on the Unified Theory of Acceptance and Use of Technology (UTAUT), the author adds four dimensions: perceived risk, perceived value, perceived interactivity and individual innovation, constructed an extended structural equation model of acceptance and use of technology, and analyzed the variable path relationship.

Results: In this study, the factor loading is between 0.61 and 0.98; the overall Cronbach's Alpha coefficients are >0.7; The composite reliability ranges from 0.59 to 0.91; the average variance extraction ranges from 0.51 to 0.85, which shows the good reliability, validity, and discriminant validity of the constructed model. The influencing factors of the behavioral intention of the older adults to accept the health management system are: effort expectation, social influences, perceived value, performance expectation, perceived interactivity and perceived risk. Effort expectation has a significant positive impact on performance expectation. Individual innovation positively impacts performance expectation and perceived interactivity. Perceived interactivity and behavioral intention have a significant positive effect on the use behavior of the older adults, while the facilitating conditions have little effect on the use behavior.

Conclusions: This paper constructs and verifies the extended model based on UTAUT, fully explores the potential factors affecting the use intention of the older adult users. According to the research findings, some suggestions are proposed from the aspects of effort expectation, performance expectation, perceived interaction and perceived value to improve the use intention and user experience of Internet-based health management services in older adults.

KEYWORDS
remote health management, behavioral intention, UTAUT, structural equation model, user experience, aging design

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1. Introduction

Aging has become one of the major problems faced by all countries in the world. In China, with the increase in the proportion and number of the older adult population, the serious aging, the coexistence of multiple chronic diseases, and the increase in medical expenses, this has brought a heavy burden of older adult care and huge economic challenges to medical institutions, older adults care institutions and even society. The health of the older adults has risen to a national strategic problem, and it is urgent to explore and open up new ways to manage the health of the older adults.

The concept of "health management" was first born in the United States and Canada. It specifically refers to the monitoring of health status, analysis of health data, evaluation and prediction of different populations, proposal of corresponding health plans, intervention and management of various potential risk factors, and supply of professional health guidance and services (1). The management system for the older adults derived from telemedicine (2) is based on Internet of Things, Internet of Systems and wireless body area networks, providing the older adults with an online self-health management platform to realize health information collection, health assessment, health consultation, emergency medical assistance and other functions. It has the advantages of real-time monitoring, two-way data transmission, online communication (3). Although older adults health management systems have been shown to have a significant physical and psychological impact on health levels (4) there remains the problem of low use rate, frequency of use, and acceptance of health management systems by the older adults. Therefore, it is meaningful to construct a health management system based on telemedicine for the older adults at present.

This study will focus on the potential older individuals who can actively use telemedicine, eliminate the special populations with senile dementia, trauma and tumors, and integrate previous studies to divide the health management content into four categories: health monitoring, chronic disease management, rehabilitation management, and accidental injury prevention. The Unified Theory of Acceptance and Use of Technology (UTAUT) is widely used to analyze users' usage behavior and intention. We will make appropriate expansion of the model and analyze the influencing factors of use behavior in older individuals through empirical research. The theoretical background and research hypotheses will be introduced in detail below, the results of the data and the final model will be analyzed, and the findings, significance, limitations, and future prospects of this study will be discussed.

2. Literature overview

2.1. Evolution of health management model and corresponding theoretical research

Health management is a systematic process of comprehensively monitoring, analyzing, evaluating, providing targeted scientific health information and intervening on potential health risk factors for the health of individuals or groups, and planning, organizing, directing, coordinating and controlling information and resources related to human health (5). Health management of the older adults is a relatively new concept derived from the concept of health management. The older individuals are characterized by susceptibility to disease and a high proportion of chronic diseases, and is the key population for health management. Health management of the older adults refers to the comprehensive detection, analysis and evaluation of the health status of the older individuals and groups, and then provide health counseling and guidance to the older adults, develop health risk factor intervention plans for the older adults and carry out the whole process of chronic disease prevention and control, disease diagnosis and treatment, rehabilitation nursing, long-term care, etc. for the older adults.

At present, there have been some studies on the health management of the older adults. Under the multiple burdens of aging and compression of health care resources, the United States government has shifted the focus of health management from "diagnosis and treatment" to "prevention and maintenance." A national health management program, the "Health People1990" program, was developed (6), which set the older adults as a national goal. The United Kingdom and other European countries have followed the relevant approach. The United Kingdom has established a variety of projects such as the National Health Service System and NSF for older people (7). Japan is a country with serious aging and early health management in Asia. The success of "u-Japan Strategy" has brought about the development of telemedicine in Japan (8).

In 1998, China introduced the concept of "health management" and based on the advanced experience of health management in the United States, and initially established a primary health management system from health examination, health file management, health risk assessment, health education, healthy lifestyle guidance, intervention of health risk factors, disease management. At present, most of the representative health management systems rely on Internet, cloud platform and other information and communication technologies, develop and integrate internal and external information resources, deepen the form and degree of cooperation with medical service providers through mobile application (WeChat, etc.) SMS, telephone and other means, and establish a core system for health management business. Nowadays, with the development of science and technology and the mature subdivision of health management, the Internet of Things, 5G network, cloud computing platform, wearable and implantable sensing technology are bringing a brand-new medical ecosystem that can rely on each other to China.

Although the health management system has become a link in the daily life of Chinese people, the search of the relevant literature (9, 10) revealed that there are significant deviations in its acceptance, which are susceptible to various factors such as age, education, income and self-perceived health status. Studies have shown that the applicability of telemedicine to the older adults has not become an obstacle to their acceptance of telemedicine services, and the older adults are very interested in the use of telemedicine services (11). There are many studies on the factors affecting the health acceptance of the older adults abroad, while the Chinese studies are not rich enough in this area. The content of this paper is the acceptance of the new health management model under the integration of telemedicine and the factors that affect the behavioral intention of the older adults to use the remote health management system.

2.2. Definition of telemedicine and its application in older health management

The World Health Organization defines telemedicine as "health care practice using interactive audiovisual and data communication."

This includes the supply of health care services, diagnosis, counseling, treatment, and health education and transfer of medical data (12). Telemedicine is divided into three types: synchronous and asynchronous, data transmission and storage, automatic and robotic telemedicine services (13). As an open, shared and evolving science, telemedicine continuously integrates new advances in information and communication technologies to meet socio-economic development and changing public health needs to achieve the key objectives of providing medical services and information exchange across regions and without time constraints (14).

With the development of various emerging technologies, as well as more powerful and convenient handheld devices (15), telemedicine has achieved the use of intelligent devices to record and upload health data at any time, and conduct information consultation with doctors anytime and anywhere (16). The transformation of telemedicine mode has changed health management from medical institution-led to "patient-centered" (17) individual spontaneous management. In this evolution trend, health management has been smoothly integrated into telemedicine, thus there is a saying of remote health management. Remote health management refers to a new health management model that combines Internet, Internet of Things, cloud computing and other technologies with monitoring equipment, transmits the collected health data to the monitoring platform, analyzes and evaluates the health data of patients through the monitoring platform, and gives individualized reminders, suggestions and interventions according to the health data of patients (18).

According to relevant statistics from the China National Committee on Aging, 75.8% of the older adults suffer from at least one chronic disease (19). This self-health management of chronic diseases in the older adults based on Internet of Things is to extend the coverage of medical services to families, emphasize the degree of individual independent participation on the basis of traditional health management, and shift the focus of monitoring, evaluation, intervention and tracking from medical institutions to families and individuals. With the help of Internet of Things, telemedicine and self-service medical model, older patients with chronic diseases may dynamically collect and analyze physiological signs information through physiological index monitors and health scales, monitor physical conditions in real time, and improve their self-health (20).

Remote rehabilitation is considered to be a means to provide rehabilitation services to patients at home, and its benefits lie in the ability to overcome geographical, physical, and cognitive impairments and compensate for the shortcomings of traditional treatments subject to hospitals (21). Such as remote rehabilitation using wearable muscle sensors and Kinect (22). Accidental injury, unlike common diseases, is physical injuries outside of everyday situations, and the prevention aims to provide personalized assistance services for the older adults in emergency situations (23). Falls tend to be the main cause of fatal and non-fatal injuries in the older adults (24), and remote fall monitoring allows the older adults to receive timely assistance (25). Remote monitoring can also be used to predict sudden hypertension in the older adults under special circumstances (26, 27). And instructional alerts are immediately sent to physicians in case of emergencies (28). Therefore, based on the above analysis, this paper defines telemedicine management in the older adults as health surveillance, chronic disease management, rehabilitation management, and accidental injury prevention.

2.3. Model analysis

The UTAUT theory model which was first proposed by Venkatesh et al. (29) is used in this study. It is a comprehensive model containing eight models and prominent theoretical models, which aims to predict and explain users' behavioral intention to use information technology and their use behavior. The model is composed of four core variables and four moderation variables. The four core variables are performance expectation, effort expectation, social influences and facilitating conditions, and the moderation variables include gender, age, experience, and voluntariness of use, of which performance expectation, effort expectation and social influences directly affect the behavioral intention, and the facilitating circumstances and behavioral intention directly affect the use behavior, and gender, age, voluntariness of use and experience play a moderating role (29). According to research, more than 40% of information technology failures may be due to lack of full recognition of how individuals or organizations accept and use technology, and information technology can better provide services only if it is accepted and used by users (30). The popularization and application of the health management system is not only related to technology and services, but also closely related to the acceptance of the older adults. At present, the use frequency of emerging health management systems by the older adults is not high, and the acceptance of emerging health management systems is far lower than that of other age groups. Therefore, this paper will use the UTAUT model combined with the characteristics of the older adults and health management system to study the factors affecting the behavioral intention of the older adults to use the health management system.

3. Hypothesis and research model

3.1. Model presentation

Acceptance refers to the behavioral intention within the user group to use ICT to accomplish tasks supported by their design. Among them, the Unified Theory of Acceptance and Use of Technology (UTAUT) model is a derived model of the Technology Acceptance Model (TAM) model, which is able to explain 69% of intention technology acceptance, while other models can explain only about 40% of technology acceptance (29). Many scholars have studied technology acceptance using the UTAUT model. Some scholars (31, 32) used modified UTAUT models to analyze health care professionals' acceptance of electronic medical records. Other scholars (33, 34) explored possible influencing factors of mobile medicine using the UTAUT model. Therefore, UTAUT is considered to be the most consistent model mentioned above, and it is also the most active model used in technology acceptance research in the field of healthcare (35). The application of UTAUT model to the acceptance and use of information and communication technologies (ICT) by the older adults within the healthcare domain will expand the understanding of the robustness of the model in explaining the acceptance and use.

To adapt to the research presented here, we will adjust these structures and definitions from the original UTAUT model. The UTAUT model was originally used to measure the acceptance of technology in the organizational environment. When adjusting the measurement factors of the model, the perspective of the older

adults and the background of health care must be considered (36). In this paper, we retain the four core elements in the original UTAUT model: Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and Facilitating Conditions (FC). The reasons for retaining the core variables are as follows: these four core elements are important indicators of studying users' behavioral intention to use information technology. The original author concluded after validating the UTAUT model in six different organizations that performance expectation, effort expectation, and social influence are direct determinants of behavioral intention, and behavioral intention and facilitating conditions directly affect use behavior, so they are retained (29). The four moderation variables (gender, age, voluntariness of use and experience) are removed from the original model. The reasons for removing the moderation variables are as follows: The subject of this study is the older individuals over 60 years old, whose age is relatively concentrated, so the moderation variable of age is removed; secondly, the development of the older health management system in China is still not very mature, and there is less reference in practical experience and voluntariness of use in terms of acceptance, so the experience and voluntariness of use are not included. In order to more accurately and comprehensively explore the influencing factors of the older adults accepting health management system, four variables of perceived interactivity, perceived value, perceived risk and personal innovation are added according to the characteristics of the older adults and health management system to jointly construct the initial model framework suitable for this study. In order to verify the relationship between performance expectation, effort expectation, social influences, facilitating conditions, perceived risk, perceived value, perceived interactivity, personal innovation and their behavioral intention to use remote health management, we developed a conceptual model based on the UTAUT model outlined in the literature review (Model Figure 1), defining the relevant variables of the model and proposing research hypotheses.

3.2. Formulation of the research hypotheses

3.2.1. Performance expectancy

Performance expectancy refers to the degree to which an individual believes that using the system will help him or her to attain gains in job performance. Performance expectation comes from the perceived usefulness introduced in the original TAM model (29, 37). In the context of telemedicine, usefulness can be regarded as the degree to which the older adults subjectively believe that the use of remote health management systems can improve or help their own health benefits and reduce personal health threats. Of the 116 studies on the relationship between performance expectation and behavioral intention, 93 studies (80%) found a significant relationship between the two (38). The key for users to accept information technology is to perceive the usefulness of technology. The fear that technology does not achieve the expected performance usually leads to the behavior of older individuals unwilling to use the technology (39). Many studies in the medical field have proved that performance expectations have a positive impact on users' behavioral intention (40). When the older adults perceive that the health management system can improve the efficiency of their own health management, which is beneficial to themselves, the behavioral intention is strong. Therefore, the hypothesis is put forward:

> H1: Performance expectation has a positive impact on the behavioral intention of the older adults to use remote health management.

3.2.2. Effort expectancy

Effort expectation refers to the degree of ease associated with the use of the system and come from perceived ease of use introduced in the TAM model (29). In this paper, it refers to the degree of ease that the older adults perceive to use the health management system. Previous studies have shown that effort expectation has a strong impact on the extent to which users accept new technologies, especially for the older individuals (41), who tend to encounter more barriers to use new technologies than other ages, and thus tend to have a lower behavioral intention to use new technologies (42). Mohammed-Issa demonstrated that perceived ease of use had a positive effect on perceived usefulness (43). That is the ease of use of telemedicine services by the older individuals strongly affects their behavioral intention to use the service and affects their acceptance behavior (36). If the health management system is simple and easy to operate, the older adults are willing to use it and will be easier to find the usefulness of the management system. Therefore, the hypothesis is put forward:

> H2: Effort expectation has a positive impact on the behavioral intention of the older adults to use remote health management.
>
> H3: The effort expectation of the older adults for remote health management positively affects the performance expectation.

3.2.3. Social influence

Social influence refers to the degree to which an individual perceives that important others believe he or she should use the new system (29). It here refers to the extent to which the older adults use health management systems because they are influenced by people around them. Of the 115 studies investigating the relationship between social influence and behavioral intention, 86 studies (75%) found that social influence had a significant impact on behavioral intention (38). In the field of medical health, Lu et al. found that social influence had a positive impact on users' behavioral intention to use information technology (44). Then, in the social environment where the older adults live, their subjective views on new technologies often depend on the evaluation of new technologies by their relatives and friends or children and grandchildren. When they feel support, encouragement or recommendation, the behavioral intention of older adults to use it will be relatively higher, and the older adults will be more willing to try it. Therefore, the hypothesis is put forward:

> H4: Social influence has a positive impact on the behavioral intention of the older adults to use remote health management.

3.2.4. Facilitating conditions

Facilitating conditions refer to the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system (29). In this paper, it refers to the extent

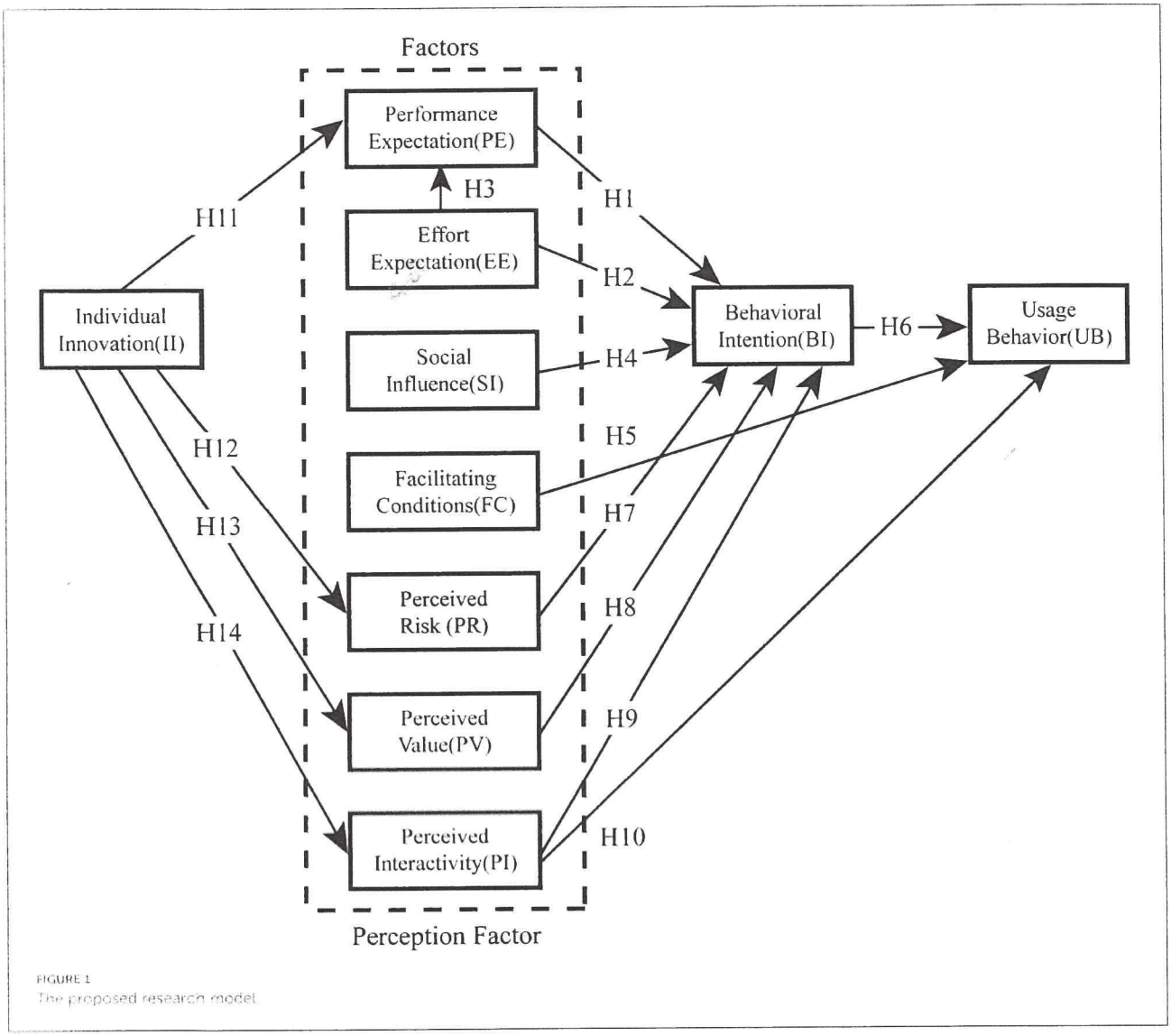

FIGURE 1
The proposed research model

to which the older adults have conditions that can be supported when using remote health management systems. Williams et al. investigated 54 studies of the relationship between facilitating conditions and behavioral intention and stated that 36 studies (67%) demonstrated a significant impact of facilitating conditions on use behavior (38). Yi et al. demonstrated in their study that facilitating conditions are direct determinants of use behavior of technology (45). The older health management system in this study is a remote online service platform that needs to be used on devices that support networking, and having devices that support the use of health management systems will promote the use of this management system by the older adults. Therefore, the hypothesis is put forward:

H5: Facilitating conditions have a positive impact on the behavior of the older adults to use remote health management.

3.2.5. Behavioral intention

Behavioral intention refers to an indication of an individual's readiness to perform a given behavior. In this paper, it refers to the tendency of the older adults to use the remote health management systems. A review of the UTAUT model shows that of the 61 studies on the relationship between behavioral intention and use behavior, 51 (82%) studies proved that behavioral intention has a positive effect on use behavior (38). Venkatesh et al. (29) empirically demonstrated the significant positive effect of behavioral intention on the use behavior and suggested that behavioral intention is a valid influencing factor of actual use behavior. Therefore, the hypothesis is put forward:

H6: Behavioral intention of the older adults to use health management systems positively impacts their use behavior.

3.2.6. Perceived risk

The original concept of perceived risk comes from psychology. Perceived risk can be understood as uncertainty about the possible adverse consequences of using a product or service. Uncertainty refers to the user's perception of whether a risk will arise when performing a certain behavior, that is, the risk to be taken before the decision is made; adverse consequences mainly refer to the

dangerous consequences resulting from the occurrence of a risk (46). Considering the conservative psychological characteristics of the older adults and the relatively new characteristics of telemedicine, this paper defines the perceived risk as various risks that the older adults may subjectively judge before using telemedicine management, such as money risk, time risk, privacy risk, etc. Wu J et al. pointed out that perceived risk had a significant negative impact on behavioral intention of users, and users would hesitate or doubt due to problems such as asymmetry of information, diversification of information, and redundancy, which played a certain role in hindering the use of new things (47). As an emerging remote service platform, the older adults have various concerns due to technical barriers, which will reduce the behavioral intention to use remote health management systems. Therefore, the relevant hypothesis is put forward:

H7: Perceived risk has a negative impact on the behavioral intention of the older adults to use remote health management.

3.2.7. Perceived value

From the perspective of consumer psychology, the perceived value of consumers was an evaluation of the overall consumption experience of the utility of products or services by consumers by weighing the perceived benefits throughout the consumption process against the costs paid when obtaining products or services (48). Value is a subjective construct, and different people have different perceptions of value. For example, the older adults with chronic diseases will think that the most valuable part of remote health management is chronic disease management, but for the older adults without chronic diseases, daily health monitoring is the most valuable. Several studies in the retail field have demonstrated that the perceived value of users has a positive impact on behavioral intention (49, 50). This paper mainly studies the acceptance of health management systems by the older adults under telemedicine. The older adults are unfamiliar with telemedicine management, and if the older adults predict that the system can meet their needs for health management, it will increase the desire to use the system. Therefore, the hypothesis is put forward:

H8: Perceived value has a positive impact on the behavioral intention of the older adults to use remote health management.

3.2.8. Perceived interactivity

Perceived interactivity is defined as "the extent to which users perceive their experience as a simulation of interpersonal interaction and sense they are in the presence of a social other (51)." McMillan envisioned perceived interactivity as three overlapped dimensions: two-way communication, control of navigation/choices, and time to load/time to find (52). Since this paper explores the influence factors of the older adults' acceptance of remote health management, it is necessary to combine the characteristics that remote health management is a new concept in China, and define the perceived interactivity in this paper as "the information exchange experience that the older adults expect to perceive in the face of remote health management system." Jee and Lee (53) found that there is a positive relationship between perceived interactivity and attitudes toward the website. The older adults often need a straightforward and efficient experience due to physiological and psychological reasons. When they think that the information exchange method of the system is in line with their usage habits, they will be more willing to use the system. Therefore, the hypothesis is put forward:

H9: Perceived interactivity has a positive impact on the behavioral intention of the older adults to use remote health management.

H10: Perceived interactivity has a positive impact on the use behavior of the older adults to use remote health management.

3.2.9. Individual innovation

Individual innovation is the ability of an individual to be good at discovering and accepting new things. It is used to assess an individual's acceptance of new things (54). Individual innovation is an important indicator to measure the acceptance of new products or technologies by users. Al Busaidi found that in the context of e-learning, learners with more innovative spirit had a positive perception and usefulness of e-learning (50). This paper mainly studies the acceptance of health management systems by the older adults under telemedicine. Therefore, the older adults with strong individual innovation are more sensitive to new information technology and more easily accept and adapt to the integration of telemedicine and health management. Such older adults often pay more attention to the development of new technologies and can give feedback on the current development trend or service experience of telemedicine, and their risk perception ability is stronger than that of others. The older adults with strong individual innovation have relatively high operational ability, their interactive experience perception of the new system is also more real, and the tendency of use is higher. Therefore, the hypothesis is put forward:

H11: Individual innovation of patients positively impacts effort expectation of behavioral intention to use remote health management services.

H12: Individual innovation of patients positively impacts perceived risk of behavioral intention to use remote health management services.

H13: Individual innovation of patients positively impacts perceived value of behavioral intention to use remote health management services.

H14: Individual innovation of patients positively impacts perceived risk of behavioral interactivity to use remote health management services.

4. Materials and methods

4.1. Research objects and questionnaire

According to the preset model diagram (Figure 1) and the hypothesis analysis of satisfaction, the study questionnaire of hospital use for patients is divided into two parts. The first part is to collect the basic information and characteristic information of users, including gender, age, educational background, income, frequency of visits, and previous use. The second part is measurement items (Table 1) which are scored on a Likert 5-level scale from 1 to 5 (from strongly disagree to strongly agree). The study was conducted in a level-A tertiary hospital in Shanghai. Before the formal distribution of the