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A home health management app designed in the post-epidemic era using empirical evidence based on the demand collection of elderly users

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In the context of the epidemic, the daily routines of China's elderly populace underwent substantial transformations. The implementation of home-based pandemic containment strategies led to heightened levels of social isolation and loneliness, exerting a discernible influence on the subjective well-being of this demographic. Consequently, residing in retirement apartments has emerged as a more advantageous alternative for elderly individuals capable of self-care. To meet their life and emotional needs and improve their sense of well-being, we used the KANO model to design a health management app for the self-care of older persons. We summarised the functional requirements for the self-care of elderly people, distributed questionnaires to generate a list of requirements, and conducted data analysis. We optimised the low-fidelity prototype based on the usability test results combined with relevant interface design elements to implement emotional interaction design practices for older persons' self-care. Furthermore, we completed a design evaluation and program optimisation of the design practice to guide the final visual design. The research findings identify the core principles of interactive design for elderly users to enable visual design specifications for improving the lives of the elderly population. This research highlights the need to design more appropriate products that meet demographic characteristics. This work contributes to strengthening the connection between elderly people and society while bridging the 'digital divide' based on this population's cautious approach to technologies and declining abilities to learn.

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Introduction

The impact of the 2019 coronavirus disease (COVID-19) epidemic has been long-lasting and far-reaching, and the social barriers exposed in this era are particularly acute. With the development of the epidemic, contact-free vaccination measures have become useful for meeting this challenge. However, special groups, such as elderly and disabled people, are particularly vulnerable to isolation in contact-free epidemic prevention, and the 'digital divide' barrier that exists has been exposed. In the case of elderly people, for instance, the epidemic era has limited the scope of their activities, which has prevented many elderly people with chronic diseases from receiving timely medical treatment (Zhu and Hou, 2021 and Jonauskaite et al. 2019). A barrier-free and intelligent health care system for elderly people in the epidemic era has not yet been developed. On the one hand, home isolation during sequestration has caused physiological insecurity in elderly groups, and on the other hand, it has generated triggers for their psychological conflicts. Due to their circumstances, some elderly people are unable to isolate themselves at home alone, so retirement apartments have become a popular solution for these groups. Postepidemic, there is an urgent need to develop software products that meet the operating habits and interactive behaviours of elderly people and eliminate the 'digital divide' while improving the welfare of elderly people and enhancing their sense of belonging to society.

Improving the lives of older persons by recognising needs has social value, and conducting this study can help elderly people by promoting their connection to society, reducing their loneliness and insecurity, increasing society's attention to them and providing support. This study is both timely and relevant in the current social context.

The literature shows that scholars have studied mobile health programs in the field of health management. Jeffrey et al. (2019) verified the feasibility of mobile applications. The interviews based on technology acceptance models, health information technology acceptance models (HITAMs), and mobile application rating tables concluded that diabetes patients can improve their health through self-management. Portz (2018) and Ashburner et al. (2021) investigated heart failure and atrial fibrillation symptoms in elderly people using the Locker quantity table and open feedback, developed corresponding tracking mobile applications, and studied the practicality and acceptability of this approach. Chung et al. (2020) demonstrated that insomnia cognitive behaviour therapy (CBY-I) can effectively improve the sleep quality of elderly people. Through the development of internet systems, mobile health management apps have become dynamic. Androutsou et al. (2020) developed an application that helps elderly patients perform self-assessments. An experiment by Goranson et al. (2020) showed that applications can help elderly people living alone improve their health literacy, but they have no significant impact on health. Tahsin et al. (2021) reported that medical relationships play an important role in the use of these materials. Buss et al. (2022) showed that the use of mobile health applications for elderly people and patients is not significantly different from that for other people. Berauk et al. (2018) noted that more research is required on applications that take care of elderly people to ensure that their quality and reliability are successful. They also observed that the application of research can help improve patients' nursing conditions (Wang et al. 2021). Lambrecht et al. (2021) demonstrated the potential and feasibility of mobile applications in the treatment of arthritis. The above scholars have conducted corresponding research on elderly groups and patients with diseases, demonstrating that mobile applications are feasible for health management and have certain development prospects. However, most of these studies are limited to specific illnesses and do not provide suggestions for improvement.

In terms of products and service systems in the field of health management, other scholars have performed related research. Since the outbreak of novel coronavirus pneumonia, experts, scholars, and related institutions have focused on daily home health monitoring. Yassine (2021) studied the advantages and disadvantages of smart devices and concluded that they could provide effective health monitoring and solutions for the epidemic. Qin et al. (2022) proposed a management method based on the Internet of Things within a secure environment. This may increase the proportion of immune people to a certain extent and reduce the number of infections. Self-health behaviour can also effectively help people fight COVID-19 and generally improve health (Jin et al. 2022b). The relationship between prevention and control can help improve self-care (Ye et al. 2022). These studies have shown that improving the knowledge of elderly reserves and self-care behaviours can effectively fight the epidemic. Under the normal management of the epidemic, disadvantaged groups are not skilled in using electronic products or registering obstacles in public places, such as entering and leaving hospitals. Although it is possible to improve the social welfare of the group, it is impossible to ensure that interactive instructions reduce the psychological burden pressure of the group and are out of balance through social disconnection. To this end, Yang et al. (2022) developed a sustainable nursing home medical care system that can help ambulance personnel quickly find elderly people at risk of harm and ensure their safety (Vacher et al. 2011). Epidemiological studies have shown that grip strength may be an indicator of certain factors related to death and the onset of illness. To help elderly people understand their physical conditions, Luo et al. (2019) studied and designed an intelligent grip collection and service system for elderly people. This study aimed to guide self-health by monitoring and managing elderly people to prevent health risks. Zhou et al. (2021) studied the integration model of Chinese medical and pension systems to meet the needs of elderly patients for medical and elderly care. At the same time, research shows that the self-management of elderly patients has a great impact on their health status (Putri et al. 2021), and this self-care ability is determined by the interaction of various resources and conditions. For example, older males who live with their families can also confirm this finding (Høy et al. 2007 and Frausing et al. 2022). The research of scholars on related products and service systems has provided health management solutions from different perspectives. At the same time, some medical service systems have been optimised. Despite this relief from medical pressure, research on these products is inadequate, leaving much room for improvement.

Many scholars have conducted the following studies on interface design and programming technologies in the field of health management. Health interface design is helpful for the health monitoring of elderly groups, but such applications are not widely used. The data were retrieved from the databases. Liu et al. (2021) studied the design of a friendly interface for elderly people and provided suggestions and design guidelines for future research in the field. Studies have shown that the core nature of the problem encountered in health applications for elderly patients is related to the motivation of elderly people and cognitive obstacles (Wildenbos et al. 2019). Wildenbos et al. (2018) identified four key categories that affect obstacles to mobile health availability: cognition, motivation, physical ability, and perception. In the context of the epidemic, there is increasing research on the physical and mental health of elderly people. In terms of interface interactions suitable for elderly people, Loiseau et al. (2015) studied digital technologies that support the autonomy of

elderly people, which can help improve their ability and fight loneliness. Lin et al. (2020) developed the elderly's mobile user interface ability assessment system (EMUIAES), which can improve the quality of life of older people. The mobile application developed by Blinka et al. (2021) based on sensor development can help elderly people better maintain their independence. Pradhan et al. (2020) studied the application of intelligent voice assistants in elderly individuals. Liu et al. (2018) integrated the concepts of 'health' and 'intelligence' and developed 'indoor environmental health' applications to improve the quality of users' lives. Pel et al. (2018) studied a product that can help elderly patients consult with medical professionals, support multimode interactions, and better serve elderly patients. Wu et al. (2020) studied and analysed the visual factors and situational visual expression of a smartphone interface, eventually built an interface visual design method model, and confirmed its feasibility.

The above scholars have achieved certain results in the research of interface design and program technology. With the development of program technology, the interface design has been simplified, reducing the difficulty of accessing the elderly group.

These studies are dedicated to solving the problems encountered by older users in their daily use of electronic devices, and the exposure of these problems can lead scholars to conduct relevant research. Solving these problems can help older people better adapt to today's digital age.

The establishment of large cities requires dense labour, especially given that highly educated industries' demand for highly educated talent has increased. The phenomenon of urban agglomeration has increased the number of remote areas. The elderly group often becomes a left-behind group, and the empty-nest phenomenon is intensified in elderly populations. The safety, self-care, and health management of elderly people have also become the focus of much scholarly research (Wang et al. 2020b).

There is considerable work in the programming of health management. Ha et al. (2021)'s study selected seven areas of health management. By analysing health applications, twelve applications were identified that can help elderly people conduct health management during pandemic self-isolation. Ming et al. (2020) evaluated the content and characteristics of the COVID-19 mobile application to help users choose the appropriate mobile application according to their needs. Studies have shown that health departments should strive to establish a national and international disease testing and monitoring system through monitoring social media (2020). During the epidemic, governments in many countries have attempted to use mobile medical technology to prevent and fight COVID-19. They investigated the user interface of such applications to promote the optimisation of the design for elderly users. Qin (2022) showed that during an epidemic, elderly people can quickly learn new technologies required for remote health. Chang et al. (2022) suggested integrating previous research results to generate a prototype website that enhances availability, making users more able to obtain credible information more expediently. Li et al. (2021) considered different types of tasks and information systems for user experience while reviewing how this can affect users' evaluation of the interactive design of specific systems. Eventually, an online information system was created from the website structure, organisation, and display. Health care professionals directed cancer patients to COVID-19-related websites that were evaluated as reliable in this study, which may have helped patients access information resources (Jin et al. 2022a). Loveys et al. (2021) found that digital human technology can provide remote psychological support for high-risk people during the COVID-19 popular period and further studied digital human technology to improve availability and effectiveness. The above scholars' research is based on different fields, such as mobile health, medical systems, and prototypes, and seeks to analyse or optimise the technical means of corresponding programmes to improve their practicality and use. However, there are still some gaps in knowledge that are not involved, and there is demand for these data.

Under the influence of the epidemic, the happiness of elderly people in China has declined, and the barrier-free and intelligent elderly medical security system is not perfect. Therefore, research on healthy ageing has positive significance and value. In the field of health management, research on mobile health program development, product and service systems, interface design and program technology, and program technology optimisation has a systematic research context, but these studies tend to remain at the theoretical level, lacking value for reality. For the elderly group, the existing mobile health management-related products do not take into account their operating habits and interactive behaviours. Taking this as an entry point, we attempt to resolve these research gaps to protect the welfare of elderly users and improve their health and social status. To this end, this paper makes the following contributions: 1. The design pain points and design opportunities are identified through research. Then, the list of user needs is sorted. 2. The KANO model is used to analyse the demand priority of the functional points, and the functional development sequence is obtained. 3. A set of senior-friendly app interface design schemes was constructed, interactive design principles for elderly users were proposed, and visual identity specifications were formulated.

Methodology

Analysis of user and functional elements. In this paper, we research and analyse the self-care needs of elderly people and construct a user model. Then, we combine the user model to explore the design requirements and user pain points of the self-care needs of elderly individuals, summarise the functional requirements of the elderly friendly service platform, and prioritise the key requirements.

User model construction. This section investigates and analyses the self-care needs of elderly people by combining qualitative and quantitative approaches to construct a user model.

Based on the results of the qualitative research involving user interviews and user behaviour observation and analysis, we summarise the factors influencing the emotional interaction of elderly people providing self-care in senior living apartments and perform three aspects of questionnaire design: physical condition, psychological condition, and behaviour style. The questionnaire was designed around the research theme of the article and included three parts: basic information of survey respondents, characteristics of users' daily life behaviours in senior living apartments, and users' usage of elderly friendly service platforms.

This questionnaire was distributed and immediately collected in the pension apartments and pension centres. Considering that the elderly group may have difficulty due to experiencing visual decline or obstacles to reading and understanding, they were assisted in reading when the questionnaire was distributed. Participants are required to be between 60 and 80 years old, have no physical disorders, have normal vision or correction, and a certain degree of academic qualifications is preferable. A random sampling method of questionnaire participants was adopted to obtain 80 completed questionnaires from the pension apartments. Due to the special circumstances of some participants, we could not insist on completing the questionnaire survey. A total of 75 valid questionnaires were obtained. The proportion of valid questionnaires was 93.75%. All the participants signed an experimentally informed consent form approved by the Moral

Table 1 Research Data Statistics.

Characteristic	Percentage	Characteristic	Percentage
Gender		Purpose of using age-friendly products	
Male	49.33	Pleasant mood	75.62
Female	50.67	Precise control capability	29.59
Educational Qualification		Body Coordination	42.73
College or above	21.33	Concentration	30.85
High School	20.00	Power of Observation	36.13
Junior High School	26.67	Communication skills	37.52
Primary School	26.67	Balancing ability	20.38
Did not attend school	5.33	Discernment	32.89
Economic Status		Exercise memory	68.32
> 10000	20.00	Others	3.30
> 8000 and < 10000	24.00	Functional requirements	
> 3000 and < 8000	42.67	Leroy gameplay	54.93
< 3000	13.33	General knowledge of aging and healthcare	75.16
Share of pension expend		Medical Institution Information	71.47
> 50	9.33	Comparison of various types of nursing homes	59.35
> 40 and < 50	8.00	National pension policy push	63.05
> 30 and < 40	20.00	Entertainment Features	58.63
>20 and < 30	37.33	Interact with friends online	39.73
< 20	25.33	One-touch call for help	58.32

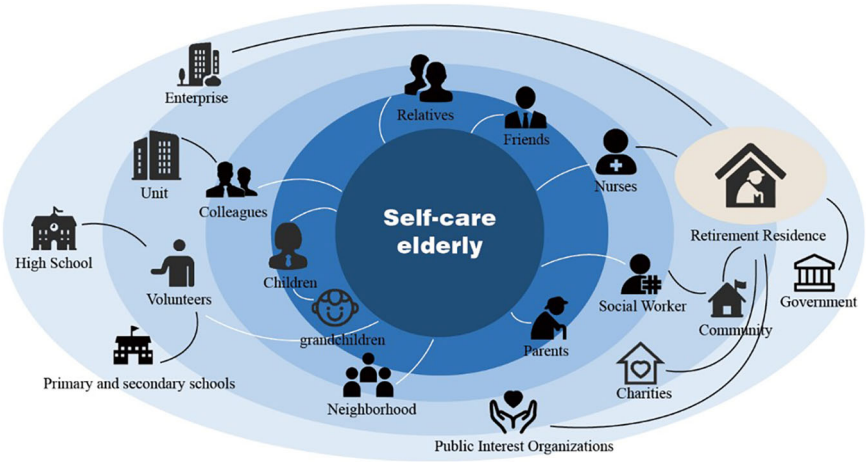

Fig. 1 Elderly self-care stakeholder map. In the elderly self-care service platform system, the retirement residence plays an important connecting role as part of the material resources. Human resources and material resources together constitute this system.

Ethics Committee. The basic information is shown in Table 1. For detailed data, see Supplemental Material Part 1.

Stakeholders are individuals and groups who can influence or be influenced by the achievement of goals. By clarifying and specifying the desired goals of stakeholders in service design, a targeted design strategy can be derived (Xiong et al. 2020 and qing Xiong et al. 2017). Related people analysis combines individuals or organisations related to users to help designers distinguish the influence of individuals or organisations on users during the service process. To find all the stakeholders as comprehensively as possible, one can traverse the four quadrants and inventory the specific stakeholders. Those who have an in-depth understanding and excavation of interests can analyse the problems from multiple angles, further segment the demands of stakeholders, and draw more specific and targeted solutions to the problems.

Stakeholders in service design include service providers, service users, and service deliverers. Expressing the relationships among these three parties in a diagrammatic manner can help summarise the importance and influence of each participant in the complex service relationship network, as shown in Fig. 1 below. The four quadrants of the 'Stakeholder Map' were traversed to look deeper into the easily ignored stakeholders and then to discover the pain points and opportunities in service design.

In the elderly self-care service platform system for elderly apartments, the apartment plays an important connecting role in the service system. Among them are two main types of human resources and material resources related to self-care. In the design of pension apartment services for elderly people, relatives, friends, children, grandchildren, neighbouring neighbourhoods, universities, community social workers, apartment caregivers, apartment property, etc., have formed human resource flows to provide emotional companionship for the establishment of emotionally interactive platforms for elderly people and service content support. Research on stakeholders can improve the design from different angles to provide effective solutions for specific needs.

The user profile of typical users helps to outline the characteristics of target users and link the needs and design directions of target users. The research object of this paper is self-care for elderly people living in retirement apartments, so the following two are selected as virtual representatives of actual users

Table 2 User profile.

Typical user I		Typical user	
Gender	Male	Gender	Female
Age	70	Age	60
Education	High school degree	Education	University degree
Interests	Calligraphy, news, raising flowers, playing chess	Interests	Sports, square dance, mahjong
User characteristics	Live alone	User characteristics	Live alone
	Chronic bronchitis		Energetic and physically fit
User requirements	Basic supplies of living materials	User requirements	Meeting social needs
	The high degree of freedom		Exposure to new things
	Continue to learn and keep up with the times		Keeping up with the times
User goals	Doing volunteer activities	User goals	Meeting new friends
	Ability to play chess and chat with friends		Learning new things
	Learn to make videos		Learn an instrument

This table is a virtual representation of the actual users from the research, helping to deeply characterize the target users and derive design requirements.

Table 3 List of emotional interaction needs of self-care elderly.

Modules	Functional requirements	Function score average	Module score average
Information	Recommendation of nearby retirement apartments based on personal geographic information	3.64	3.59
	Support the collection of each apartment and information comparison	3.60	
	Pension policy information	3.66	
	Introduction to entertainment activities in elderly care apartments	3.52	
	Point acquisition method	3.46	
	Recommended health management methods	3.78	
	Volunteer service position information	3.50	
Courses	Course push, personalized recommendation based on the entered personal information	3.80	3.78
	Course search, which supports users to search by category or course name	3.70	
	Collection of courses for further study	3.94	
	You can redeem the course content that needs to be paid through points	3.90	
	Related course recommendation, recommend other courses related to the course being studied	3.54	
Social	Set up a group to discuss topics of interest	3.84	3.75
	Topic discussion on elderly care apartment activities	3.44	
	Add friends, family members and chat privately	3.92	
	You can see and interact with your friends	3.86	
	Post personal updates	3.90	
	Support point donation	3.62	
	Points ranking	3.66	
Others	Personal health	4.10	3.80
	Medication reminder	4.04	
	My Message List	3.84	
	My current points	3.70	
	My Favorite Course List	3.72	
	My Favorite Information Article List	3.60	
	My published dynamic details	3.62	

to build user personas that combine products and markets, link user attribute behaviours, and transform expectations through plain and life-like language. Table 2 provides the user profile.

Functional requirements. Combined with previous research on self-care among elderly people and the generation of stakeholder relationship maps and typical user portraits of elderly people providing self-care, we explore in depth the demand design opportunity points and user pain points of self-care among elderly people for senior living service platforms. The functional requirements of the service platform for the self-care of elderly individuals were divided into four modules-courses, social, information, and others. The questionnaires were administered for the specific functional requirements in the four modules, and the key requirements were prioritised.

The results of the questionnaire survey on the functional requirements of the emotional interactive service platform for the self-care of elderly people were analysed for reliability and validity. To verify whether the questionnaire results are credible and valid for guiding design practice. A total of 50 valid questionnaires were collected, including 25 from males and 25 from females. For detailed data, see Supplemental Material Part 2. Analysing the reliability and validity results of the questionnaire data, the alpha reliability coefficient was 0.994, greater than 0.8, indicating that the reliability of the scale was very good. The KMO value was greater than 0.6 and close to 1, indicating that the structural validity of the scale was better for each question. The p value is less than 0.01, indicating significant differences between the items and that the scale as a whole has validity. The emotional needs of elderly individuals

Table 4 List of emotional needs of self-care elderly.

Modules	Functional requirements
Information	Recommended health management methods
	Pension policy information
	Recommendation of nearby retirement apartments based on personal geographic information
	Support the collection of each apartment and information comparison
Courses	Collection of courses for further study
	You can redeem the course content that needs to be paid through points
	Course push, personalized recommendation based on the entered personal information
	Course search, which supports users to search by category or course name
Social	Add friends, family members and chat privately
	Post personal updates
	You can see and interact with your friends
	Set up a group to discuss topics of interest
	Points ranking
	Support point donation
Others	Personal health
	Medication reminder
	My Message List
	My Favorite Course List
	My current points

Table 5 Emotional needs number.

Requirement number	Requirement
A	Recommended health management methods
B	Pension Policy Information
C	Information on the introduction of senior citizen apartments nearby
D	Senior Living Collection and Information Comparison
E	Personalized course delivery
F	Course collection for the future learning function
G	Complete daily tasks to earn points feature
H	Redeem points for paid courses
I	Course Search Function
J	Add friends and family association function
K	Post personal news function
L	View and interact with your friends
M	Set up interest groups, create group chats, and other functions
N	Ranking of points for completing daily tasks
O	Bonus point function
P	Personal health record function
Q	Medication reminder function
R	My current point status list function
S	My favorite course status list function
T	My Message List function

receiving self-care are listed in Table 3, and the table lists the scores for each emotional need.

The questionnaire results were used to rank the functional requirements according to the priority of functional requirements for the development of interactive service platforms for elderly individuals receiving self-care. Low-frequency and less frequent needs are abandoned, and high-frequency pain points are the main development functions. Based on the analysis of the results of the scale questionnaire of the above list of emotional needs, the demand points of each module are sorted and deleted. In addition, the list of requirements of the interactive service platform for the self-care of elderly people in senior living apartments is obtained, as shown in Table 4, which provides a functional research basis for the subsequent system construction of the interactive service platform.

Experimental stimulus materials.

(1) The demand priority research questionnaire was selected as the stimulus material for the experiment.
(2) Experimental instructions, including an introduction to the experimental procedure and precautions, were provided to the subjects before the experiment started.
(3) An iPad was used to complete the demand prioritisation questionnaire.

Experimental subjects. A total of 60 subjects, including 30 males and 30 females aged 60-80 years with normal vision or corrected vision, participated in this experiment. Before the experiment, the subjects were asked to complete a questionnaire about basic feature perception, including name, gender, visual discrimination, and colour preference.

Experimental Steps. (1) Relevant subjects were recruited based on the following criteria: age between 60 and 80 years old, no physical impairment, normal vision or corrected vision, some education to be literate, and 1 year or more of experience with electronic devices. Efforts were made to obtain an equal number of males and females. All subjects signed an informed consent form for the experiment, which was approved by the ethics committee.

(2) Subjects entered the laboratory and were informed of the experimental task and purpose, and the experimental requirements, as well as precautions, were explained to the subjects. The subjects were asked to complete the questionnaire to prioritise their functional needs in the laboratory, which required that the laboratory was free from disturbances by uninvolved persons and that the laboratory environment was at a certain temperature and humidity with good lighting. The questionnaire is shown in Table 5.

(3) After the subjects completed the task, the experimenter collected the questionnaires, and the experiment was finished.

Data analysis

The KANO model was originally invented by Noriaki Kano (1984) and named after him in 1984. The original purpose of the design was to assist in requirements classification and prioritisation and establish a nonlinear relationship between product performance and user satisfaction. It is often used to mine users' needs that are difficult to express accurately but exist in the heart. The KANO model is widely used in design practice. It divides users' needs into five categories: basic needs, performance needs, excitement needs, indifferent needs, and reverse needs.

The above service platform design principles for the self-care of elderly individuals suggest reducing the information layer design to allow elderly people to complete the interactive tasks more easily; therefore, when designing the interactive service software for elderly individuals receiving self-care, we should first research and analyse the list of functions again according to the list of functional requirements and use the KANO model to analyse the order of requirement development to distinguish the basic functions and value-added functions among the many functions that users need. The KANO model is used to analyse the sequence of requirement development and to identify the basic functions and value-added functions among the many functions required by users.

Table 6 Summary of KANO model analysis results.

Number	A	O	M	I	R	Q	Classification results	Better	Worse
A	8	10	6	16	10	0	Indifferent quality attribute	0.45	−0.40
B	10	4	7	19	10	0	Indifferent quality attribute	0.35	−0.28
C	9	9	9	16	7	0	Indifferent quality attribute	0.42	−0.42
D	10	5	13	10	12	0	Must-be quality attribute	0.39	−0.47
E	7	3	8	20	12	0	Indifferent quality attribute	0.26	−0.29
F	9	9	12	11	9	0	Must-be quality attribute	0.44	−0.51
G	6	4	17	11	12	0	Must-be quality attribute	0.26	−0.55
H	9	15	8	9	9	0	One-dimensional quality attribute	0.59	−0.56
I	8	3	18	15	6	0	Must-be quality attribute	0.25	−0.48
J	16	7	6	10	11	0	Attractive quality attribute	0.59	−0.33
K	5	6	9	20	10	0	Indifferent quality attribute	0.28	−0.38
L	12	4	5	19	10	0	Indifferent quality attribute	0.40	−0.23
M	10	5	10	18	7	0	Indifferent quality attribute	0.35	−0.35
N	8	5	11	16	10	0	Indifferent quality attribute	0.33	−0.40
O	12	5	8	18	7	0	Indifferent quality attribute	0.40	−0.30
P	9	5	8	18	10	0	Indifferent quality attribute	0.35	−0.33
Q	20	6	6	10	8	0	Attractive quality attribute	0.62	−0.29
R	9	8	6	16	11	0	Indifferent quality attribute	0.44	−0.36
S	16	7	6	8	13	0	Attractive quality attribute	0.62	−0.35
T	9	6	10	16	9	0	Indifferent quality attribute	0.37	−0.39

The questionnaire was designed and distributed to the list of the self-care needs of elderly individuals. A total of 60 questionnaires were distributed, of which 58 were valid, yielding a validity rate of 96.7%. For detailed data, see Supplemental Material Part 3. The information collected was calculated according to the KANO model evaluation result comparison table presented in Table 6, and the results of the questionnaire were analysed. A: attractive; O: one-dimensional; M: must-be; I: indifferent; R: reverse; Q: questionable.

Based on the KANO model data of the demand for the functions of the interactive service platform for the self-care of elderly individuals in the nursing home, the scatter plot distribution coordinates of each function are calculated using the better-worse coefficient. The better coefficient, with a positive result, indicates the satisfaction coefficient of users after adding a certain function. The worse coefficient, with a negative result, indicates the dissatisfaction coefficient after not providing a certain function.

After completing the analysis table, the number of each combination for each question was calculated according to Equation (1) and Equation (2).

$$\text{Better/SI} = (\text{A} + \text{O})/(\text{A} + \text{O} + \text{M} + \text{I}) \quad (1)$$

$$\text{Worse/DSI} = -1 \cdot *(\text{O} + \text{M})/(\text{A} + \text{O} + \text{M} + \text{I}) \quad (2)$$

The better coefficient and worse coefficient of each function point are aggregated, and the mean value is calculated. The absolute value of the worse coefficient is used as the x-axis, and the better coefficient is used as the y-axis. The mean value is used as the centre point to plot the four quadrants of the better-worse coefficient in an Excel sheet, and the four quadrants are labelled with the charm attribute, desired attribute, undifferentiated attribute, and required attribute. The original information of each function was visualised in the four quadrants.

According to the distribution of each function in the four quadrants of the better-worse coefficient in Fig. 2, the essential requirements include comparing senior living collections and information, collecting courses for future study, earning points for completing tasks, and searching for courses. The attractive requirements include adding friends and associating with family members, medication reminders, and the list of my favourite courses. The desired requirements include redeeming points for paid courses, and the undifferentiated requirements include health management method recommendations, information on senior care policy, information on nearby senior care apartments, personalised course pushing, posting personal news, viewing and interacting with friends' news, forming interest groups or creating group chats, point ranking for completing daily tasks, point gifting, personal health status records, my current point status list, and my message list.

From the perspective of the input-output ratio, we can determine the priority principle of each requirement in the planning of product functions: essential requirement > attractive requirement > desired requirement > no difference requirement > reverse requirement. The priority ranking rule of similar requirements is 'the higher the better value is, the higher the priority'. For the functional points in the four quadrants, 'nondifferentiated and reverse need' were excluded.

Therefore, the functional development of an interactive service platform for elderly people receiving self-care in senior living can occur in the following order: priority course search; complete tasks to earn points; senior living collection and information comparison; course collection for future study; medication reminders; the addition of friends and associate families; my favourite course list; and point exchange for paid courses.

Prototyping

Usability test evaluation. In this paper, we use low-fidelity interaction prototyping in the interface design module to facilitate subsequent usability testing of the product, which is conducive to the discovery of problems in the early stages of product design and problem solving to optimise product iteration.

To verify the usability, simplicity, and satisfaction of the product interactions, design evaluation entails conducting interactive task tests and user interviews on the finished low-fidelity interactive prototypes. It also involves making prompt design adjustments after issues are found to further improve the design and provide users a higher level of satisfaction and better service (Wang et al. 2020a).

Evaluation content. The evaluation of a product mainly starts from three evaluation dimensions: product usefulness, product ease of use, and product satisfaction. The content of these three

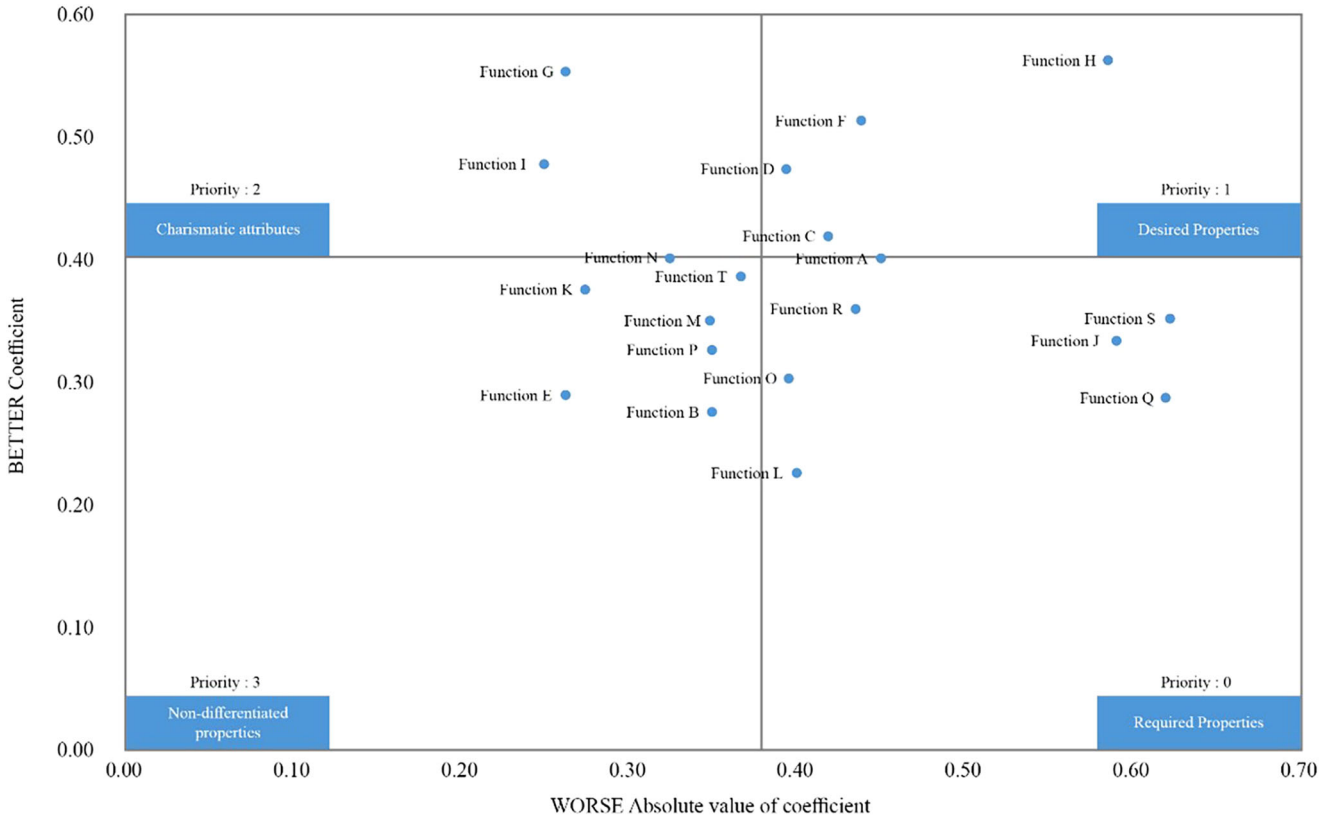

Fig. 2 Scatter plot of the better-worse coefficients of the four quadrants. The 20 functions are divided into four attributes: charm attribute, desired attribute, undifferentiated attribute and required attribute, and the requirements are prioritized.

dimensions is refined separately, and the questions are set as scale questions. The specific evaluation content is shown in Table 7.

Evaluation of the experimental design. In this research, we conducted a task test based on the low-fidelity prototype. We allowed the subjects to familiarise themselves with the product before the test and then rate their satisfaction with completing the eleven interactive tasks according to the product design evaluation form (Zhang et al. 2022).

The Nielsen usability testing method suggested that '5-6 users can find 85% of the problem', and this test recruited 6 elderly people receiving self-care to test the low-fidelity prototype and conducted in-depth interviews after each task was completed. The sample was selected based on the criteria of being 60-80 years old, having normal vision, having some education to be considered literate, and having one or more years of experience using electronic devices. Three males and three females were selected to ensure that the sample was representative. Afterwards, the subjects scored their satisfaction with the elderly self-care service platform according to the product design evaluation form and obtained the product evaluation results, which were used as the basis for prototype iteration. The test task mainly includes seven parts: collect courses, add family members, redeem points, participate in activities, publish mood status, complete daily tasks, and find favourite courses. The Huawei Mate40 test device was selected, and the true subsistence prototype was displayed using the Mo Da app (V5.3.2, Beijing, China) to complete the experimental evaluation task.

Evaluation results. According to the records and interviews of the 6 elderly people receiving self-care, the subjects were able to complete the test tasks, indicating that the interaction process was not complicated for them and that the product functions could basically meet their needs.

Based on the results of user usability testing of the above prototype, as shown in Table 8, the page was modified. The low-fidelity prototyping optimisation is shown in Fig. 3.

High-fidelity prototype interface design. The six self-care seniors who participated in the previous test were invited to score their satisfaction with the user experience according to the user experience evaluation model. The results showed a significant improvement in satisfaction with the interface design and functional requirements. In addition, the users were able to effectively access information and satisfy their personal needs during use.

Due to changes in the lens of the eye, elderly people have poor recognition of colour. Thus, colour selection in visual design should consider the perception of colour by the eyes of elderly individuals and not add a burden to elderly people in recognising colour, leading to the problem of no differentiation or recognition between the elements of product icons.

According to the analysis of colour emotion, human perceptual excitement and the sedative effect of different colours are determined by the strength of the colour stimulus. For example, red, orange and yellow are strongly irritating and can cause excitement. Blue, lime green and blue-violet can cause sedation. Green and purple are intermediate colours that make people feel fatigued when looking at them. Combined with the results of the previous study, to maintain continuous attraction and to ensure that users pay attention to the information on the page that is not too complicated to hinder access to the main navigation bar information, a single main colour, such as logo, icon, with black and white and different

Table 7 Product Design Evaluation Form.

Evaluation Dimension	Evaluation Indicators	Satisfaction score
Product Usefulness	Interesting content: I can find the part that interests me	5-4-3-2-1
	Social Attributes: I feel that communicating with people will make the relationship close	5-4-3-2-1
	Problem-solving: I feel that I can solve some of my life needs	5-4-3-2-1
	Health data: I can better manage my health	5-4-3-2-1
Product Usability	Convenience: I think it's easy to operate	5-4-3-2-1
	Usage: Similar to my usual usage habits	5-4-3-2-1
	Interface understanding: The interface icon elements are well-understood	5-4-3-2-1
	Frequent use: I would like to open it often to see	5-4-3-2-1
Product Satisfaction	Pleasure level: I had a great time using it	5-4-3-2-1
	Likeness: I like this app	5-4-3-2-1
	Willingness to recommend: I would like to recommend to people around me	5-4-3-2-1

Table 8 Summary of Usability Testing Questions.

Priority	Problem description	Severity	Solutions
1	Don't know where to add family members.	High	Front-load the add method to be uniform in size with the family avatar.
2	It was a hassle to participate in the event, and you had to go back to the top to click after reading the event description.	Medium	Change the participation position of the event detail page in the three-level interface to the bottom of the event content.
3	The switch between square and message is not obvious.	Low	Change the original bottom line switching method to color block transfer switching.

shades of grey, is chosen to distinguish the importance of the text information. At the same time, through the contrast of intuitive accent colours to provide important information highlighting, it is easy for users to complete all interactive tasks with habitual operation. Colour also enhances the user's emotional experience. Bright and stimulating colours will capture the first point of attention of users, stimulate their interest in continuous reading and enhance the pleasure of using the app. Therefore, the colour scheme of the app involves bright green and white, with black and grey as secondary colours (Yu et al. 2022b and Yu et al. 2022a). The high-fidelity prototype interface design is shown in Fig. 4.

Discussion

To enhance the sense of well-being, as well as the sense of self-worth and social identity in the lives of elderly people, a design that meets their emotional needs can effectively enhance user engagement to a certain extent while improving the positive psychology of users in their daily lives. This study analyses the emotional needs of self-care elderly individuals, summarises the list of emotional needs, and prioritises the functional needs of interactive service platforms for elderly individuals receiving self-care through KANO model analysis. The framework of an interactive service platform for elderly individuals receiving self-care is obtained, and the high-fidelity prototype interface of the 'Lelingyua' app is created.

Among them, the interaction design for elderly individuals receiving self-care should pay attention to the following five aspects: (1) the content of recreation and physical and mental health, with the main themes of pleasure and relaxation; (2) the architecture combined with health care information; (3) the operation process should be simple, intuitive and convenient; (4) strengthening social interaction attributes combined with reward mechanisms; and (5) the interface design should be easy to recognise and easy to use.

At the same time, to address the pain of elderly users when using an interactive system, reduce the influence of the 'digital divide' and increase the convenience of technology, the interactive interface should follow the design idea of improving user interaction performance. In this regard, we propose the following design principles for the interaction of middle-aged and elderly users: the overall design is reasonable, fitting the characteristics of the target users and referring to the user model; the interactive operation is efficient, reducing unnecessary interaction steps and making the design efficient, convenient and simple to operate; the interaction details are uniform, reducing the learning cost of users; the interface visualisation is simple and intuitive, with clear information; and it can be customised to meet different users' personal needs.

Based on the self-care of elderly people's colour and identification characteristics, the choice of interface visual colour can be determined, and the visual effect design of the emotional interaction software for elderly people can be completed. We used bright green and white as the main theme colours, with black and grey as the secondary colours. The following visual design specifications are formulated. In terms of the layout characteristics of the homepage, a simple and intuitive multi-column layout or card-type layout is adopted, combined with the leading navigation bar at the bottom. Regarding the choice of the main colour, the low-saturated single colour is used as the main colour, and high saturation colour embellishments play a role in highlighting key information. In terms of the information density of the homepage, the graphic to information density ratio is low. Regarding the arrangement of page content, we should try to choose high user-related correlation information. From the perspective of the implementation of the smart home interaction interface function, this study improves the rationality of the old smart home interface, enabling the smart home interface to better cope with the old scene. From the perspective of the impact of mobile health on elderly people, this study can help elderly people better master the use of mobile health services so that they can enjoy the benefits of mobile health and, in urgent situations, comply with medical information sharing and improve rescue efficiency. This study

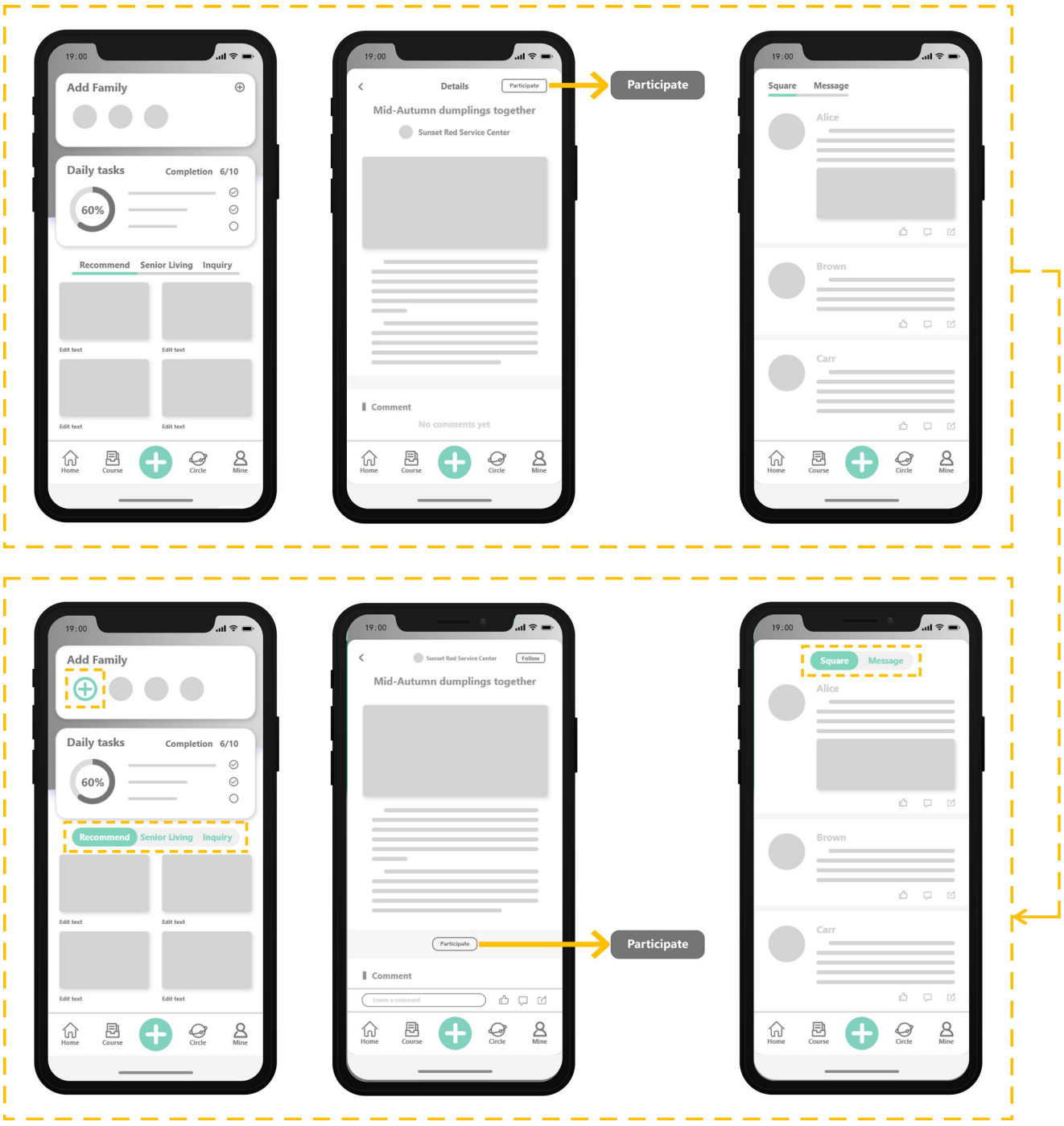

Fig. 3 Low-fidelity prototyping optimisation. Solve three problems in usability testing and optimize low-fidelity prototyping.

focuses on the study of health management applications for mobile platforms but can also serve as a guide for interface design on web sites.

Conclusion

In the postepidemic era, the barrier-free smart ageing medical security system is not yet perfect, and the living and emotional needs of elderly people receiving self-care need to be met. At the same time, there is a lack of systematic research on user experience-centred application interface design on the market at present, and the ageing-friendly transformation of smart homes is facing multiple challenges. The interfaces of the existing age-friendly products in the market have certain common problems, such as the lack of versatility and high application costs for elderly users. The ease of use of age-friendly products needs to be improved. There are no clear age-friendly standards in the industry, and age-friendly standards still have a long way to go. To achieve active and healthy ageing, it is important to consider key points, such as the specific psychological patterns and cognitive load of elderly people, and to design more comprehensive and age-friendly products that improve the connection between elderly people and society. The interaction design principles and visual design specifications summarised in the study can help

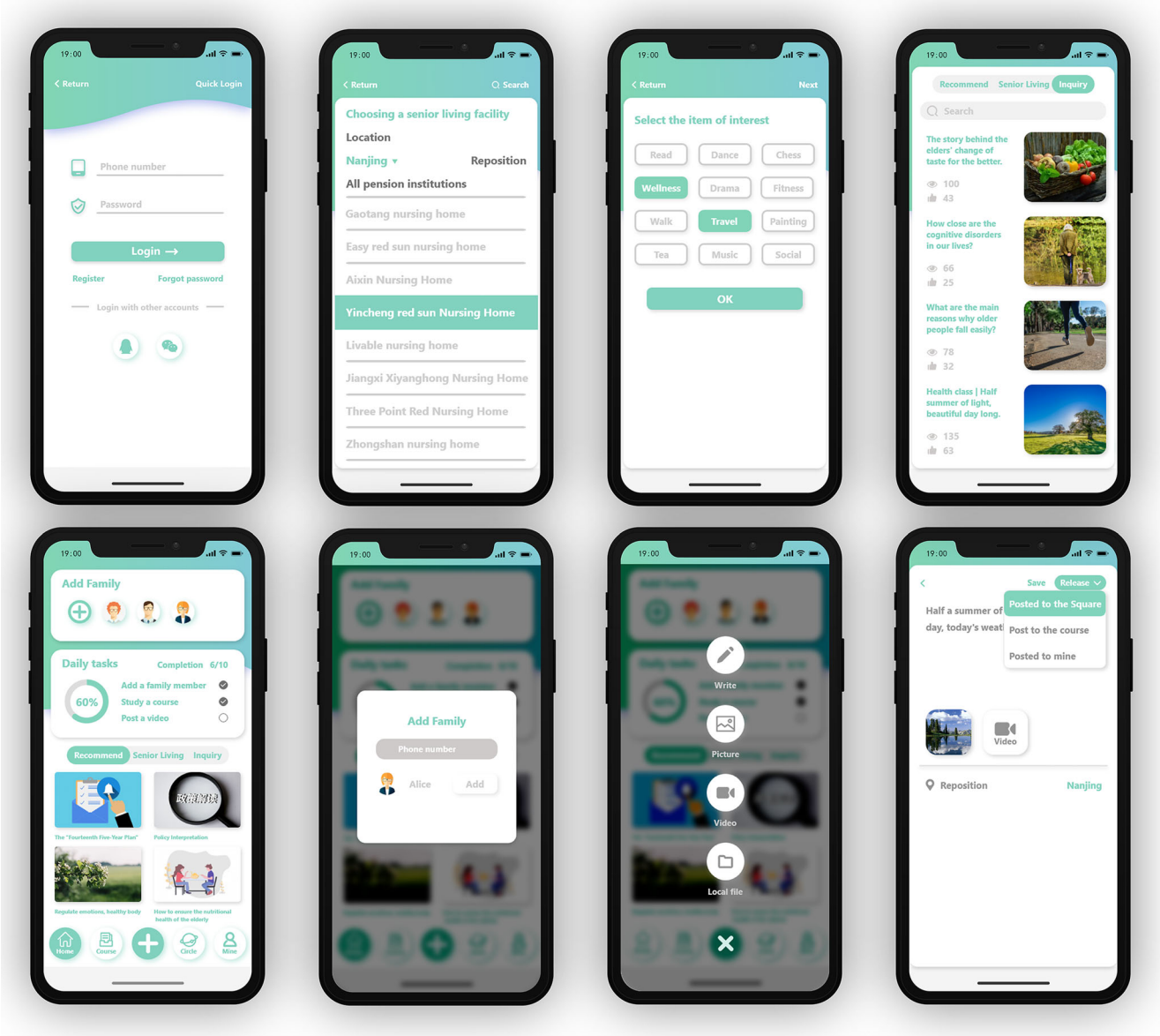

Fig. 4 High-fidelity interface display. The simulation showcases high-fidelity interfaces representing distinct stages of user experience.

subsequent scholars conduct better research and provide standardised design guidelines for designers and developers.

At the same time, we recognise the limitations of this article. Due to equipment restrictions, the user's emotional experience cannot be measured at the technical level. Only subjective satisfaction data can be collected through a questionnaire survey. Based on the experimental settings, the problems that appear in terms of the habits and needs of elderly individuals cannot be accurately obtained by the user interface. In future work, an experimental design should be used to eliminate these human problems. At the same time, we can introduce more advanced technical means to apply technology to daily life.

Data availability

The data that support the findings of this study are included in this published article and its supplementary information files.

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Author contributions

CZ developed the research plan, framework ideas and contents. JG wrote the contents and drew the diagrams. YZ and TH contributed to the manuscript and YZ performed the data collection and analysis. JK guided for language improvement, article layout and some contents. All authors have read and agreed to the published version of the manuscript.

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Competing interests

The authors declare no competing interests.

Ethical approval

All participants and/or their legal guardians gave informed consent for inclusion before participating in the study. The project was approved by the Animal Welfare and Ethics Committee of Nanjing Forestry University (Nanjing Forestry University Science and Technology Office [2021] No. 1), and the ethical review number is: 2021-12-16-10. The procedure used in this study follows the principles of the Declaration of Helsinki.

Informed consent

Informed consent was obtained by all participants and/or their legal guardians. All participants and/or their legal guardians were informed of the purpose and objectives of the study. Their participation is entirely voluntary, as is the way the data is used.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1057/s41599-024-03042-0.

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